6-A
AFFECTED ENVIRONMENT: SURFACE WATER

FINAL
ENVIRONMENTAL
IMPACT STATEMENT

Brightwater
Regional Wastewater
Treatment System

APPENDICES

King County Brightwater TREATMENT SYSTEM

Final

Appendix 6-A
Affected Environment: Surface Water

October 2003

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TABLE OF CONTENTS

List of Tables

Introduction

King County has prepared a Draft Environmental Impact Statement (Draft EIS) and Final Environmental Impact Statement (Final EIS) on the Brightwater Regional Wastewater Treatment System. The Final EIS is intended to provide decision-makers, regulatory agencies and the public with information regarding the probable significant adverse impacts of the Brightwater proposal and identify alternatives and reasonable mitigation measures.

King County Executive Ron Sims has identified a preferred alternative, which is outlined in the Final EIS. This preferred alternative is for public information only, and is not intended in any way to prejudge the County's final decision, which will be made following the issuance of the Final EIS with accompanying technical appendices, comments on the Draft EIS and responses from King County, and additional supporting information. After issuance of the Final EIS, the King County Executive will select final locations for a treatment plant, marine outfall and associated conveyances.

The County Executive authorized the preparation of a set of Technical Reports, in support of the Final EIS. These reports represent a substantial volume of additional investigation on the identified Brightwater alternatives, as appropriate, to identify probable significant adverse environmental impacts as required by the State Environmental Policy Act (SEPA). The collection of pertinent information and evaluation of impacts and mitigation measures on the Brightwater proposal is an ongoing process. The Final EIS incorporates this updated information and additional analysis of the probable significant adverse environmental impacts of the Brightwater alternatives, along with identification of reasonable mitigation measures. Additional evaluation will continue as part of meeting federal, state and local permitting requirements.

Thus, the readers of this Technical Report should take into account the preliminary nature of the data contained herein, as well as the fact that new information relating to Brightwater may become available as the permit process gets underway. It is released at this time as part of King County's commitment to share information with the public as it is being developed.

This technical appendix includes information on existing water quality and water quality regulations for the treatment plant sites and conveyance corridors to support Chapter 6 of the Final EIS. The first section of this report summarizes relevant water quality regulations. The treatment plant section provides existing water quality and quantity data for Willow Creek at the Unocal Treatment Plant site and Little Bear Creek adjacent to the Route 9 Treatment Plant site. Refer to Chapter 6 of the Final EIS for additional information.

The conveyance section of this report includes a description of the characteristics of surface waters in major basins in which the Brightwater conveyance corridors (including its connection to the existing system) and the Treatment Plant sites would be constructed. The major surface water basins described in this section include North Creek, Swamp Creek, Lyon Creek, McAleer Creek, and the Puget Sound Basins, including the water bodies of Lake Washington, Sammamish River, Lake Ballinger, and Hall Lake. Information provided for each surface water body includes the hydrologic setting, water quality (including pesticides), stream discharge flows, and sediment

data. This information is primarily based on data collected from King and Snohomish Counties and the Washington Department of Ecology (Ecology).

For information on marine water quality, see Appendix 6-I, Effluent Quality Evaluation for the Brightwater Membrane Bioreactor and Advanced Primary System.

Surface Water Quality Regulations

Washington State Surface Water Quality Standards

Surface water quality standards for the State of Washington were established by Ecology in WAC Chapter 173-201A for the protection of public health and enjoyment, and designated beneficial uses (Ecology 1997a) (Table 1). The Sammamish River, Lyon Creek, McAleer Creek, North Creek, Swamp Creek, Little Bear Creek and tributaries to Puget Sound are designated Class AA (extraordinary) surface waters by Ecology (1997a) (Table 1). Lake Washington is designated Lake Class (Ecology 1997a). Beneficial uses of Class AA and Lake Class waters include, but are not limited to water supply, stock watering, fish, wildlife habitat, recreation, commerce and navigation.

Table 1. Water quality standards for surface fresh waters of the State of Washington (Chapter 173-201A WAC) Class AA (Extraordinary) and Lake Class criteria for the Cedar-Sammamish River Basin.

Water Quality Parameter	Class AA and Lake Class Standards
Fecal coliform bacteria	Shall not exceed a geometric mean value of 50 colonies/100 mL in Class AA and Lake Class freshwaters, with not more than 10 percent of all samples exceeding 100 colonies/100 mL.
Dissolved Oxygen	Shall exceed 9.5 mg/l in Class AA freshwaters. No measurable change from natural conditions for Lake Class waters, where total dissolved gas shall not exceed 110 percent of saturation at any point of sample collection.
Temperature	Shall not exceed 16.0 °C in Class AA freshwaters due to human activities. When natural conditions exceed this limit, no temperature increase will be allowed that raises the receiving water temperature by 0.3°C. Incremental temperature increases from non-point source activities shall not exceed 2.8C. No measurable change from natural conditions for Lake Class waters.
pH	Shall be between 6.5 to 8.5, with a human-caused variation within a range of less than 0.2 units in Class AA freshwaters. No measurable change from natural conditions for Lake Class waters.
Turbidity	Turbidity shall not exceed 5 NTU over background levels when the background turbidity is 50 NTU or less, or have more than a 10 percent increase in turbidity when the background turbidity is more than 50 NTU.

Water Quality Parameter	Class AA and Lake Class Standards
Toxic, radioactive, or deleterious material concentrations	Shall be below concentrations that have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent on those waters, or adversely affect public health, as determined by Ecology.
Aesthetic values	Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste.
Characteristic uses	Shall include, but not be limited to, the following uses: domestic, industrial, and agricultural water supply, stock watering; salmonid or other fish migration, rearing, spawning, and harvesting; shellfish rearing, spawning, and harvesting; wildlife habitat; general recreation and aesthetic enjoyment; and commerce and navigation.

Source: Ecology (1997a)

Ecology adopted new water quality standards in July 1, 2003 that, pending approval by the U.S. Environmental Protection Agency (EPA), will be in effect once construction of Brightwater begins (Ecology 2003) (Table 2). The new standards reflect a use-based system for designating uses of fresh and marine waters. The old standards were class-based, with water bodies assigned to classes having a prescribed set of beneficial uses. Using the new system for designating beneficial uses, all freshwater bodies in the Brightwater project area are designated for: salmon and trout spawning, core rearing, and migration; extraordinary primary contact recreation; domestic, industrial, and agricultural water supply; stock watering; wildlife habitat; harvesting; commerce and navigation; boating; and aesthetic values. The new standards distinguish core rearing from non-core rearing for freshwater having different densities of salmon and trout under current and predevelopment conditions. Core rearing is associated with high densities of a population that is using waters within its optimal range, usually in the middle to upper reaches of a water body. Non-core rearing is associated with low densities of a population that is using waters beyond its optimal thermal range, usually in the middle to lower reaches of a water body. Marine water bodies (Puget Sound) are designated for extraordinary aquatic life uses, shellfish harvest, primary contact recreation, wildlife habitat, harvesting, commerce and navigation, boating, and aesthetic values.

Water quality standards for freshwaters that have changed include temperature and ammonia. Ecology also adopted a new bacteria indicator (enterococcus) and criterion for marine waters having a designated use of secondary contact recreation. Fecal coliform bacteria will remain the indicator for shellfish harvest water.

Table 2. New water quality standards and designated uses (Chapter 173-201A WAC) of surface waters in the Cedar-Sammamish River Basin.

Water Quality Parameter	Salmon and trout spawning, core rearing, and migration; and extraordinary primary contact recreation
Fecal coliform bacteria	Shall not exceed a geometric mean value of 50 colonies/100 mL, with not more than 10 percent of all samples exceeding 100 colonies/100 mL.
Dissolved Oxygen	Lowest 1-day minimum is 9.5 mg/L. For lakes and streams, human actions considered cumulatively may not decrease the dissolved oxygen concentration more than 0.2 mg/L below natural conditions.
Temperature	Highest 7-DADMax[a] is 16°C. When natural conditions exceed this limit, human actions considered cumulatively may not cause the 7-DADMax temperature of that water body to increase more than 0.3°C. Incremental temperature increases from non-point source activities shall not exceed 2.8°C. For lakes, human actions considered cumulatively may not increase the 7-DADMax more than 0.3°C above natural conditions.
pH	Shall be between the 6.5 to 8.5, with a human-caused variation within a range of less than 0.2 units in Class AA freshwaters.
Turbidity	Turbidity shall not exceed 5 NTU over background levels when the background turbidity is 50 NTU or less, or have more than a 10 percent increase in turbidity when the background turbidity is more than 50 NTU.
Toxic, radioactive, or deleterious material concentrations	Shall be below concentrations that have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent on those waters, or adversely affect public health, as determined by Ecology.
Aesthetic values	Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste.
Designated uses	Shall include the following: salmon and trout spawning, core rearing, and migration; extraordinary primary contact recreation; domestic, industrial, and agricultural water supply; stock watering; wildlife habitat; harvesting; commerce and navigation; boating; and aesthetic values.

Source: Ecology (2003)

[a] 7-DADMax or the 7-day average of the daily maximum temperatures is the arithmetic average of seven consecutive measures of daily maximum temperatures.

Section 303(d) Water Quality Limited List of Threatened and Impaired Waterbodies

Section 303(d) of the Clean Water Act (CWA) of 1972 (and later modifications) requires all states to prepare a list every four years of surface waters that are not expected to meet applicable water quality standards after implementation of water quality based controls. This list is prepared by Ecology and submitted to the United States Environmental Protection Agency (U.S. EPA) for their review and approval. The last list was prepared in 2002.

Prior to 2002, the CWA required States to prepare and submit 303(d) lists every two years. The U.S. EPA allowed states to skip the 2000 list because of ongoing development of new federal rules affecting the listing process and the total maximum daily load (TMDL) program; therefore, the last list prepared by Ecology and approved by the U.S. EPA for Washington State was in 1998 (Ecology 1998).

Total Maximum Daily Load

The CWA requires states to establish TMDL Programs for parameters not meeting applicable water quality standards identified on their 303(d) water quality limited lists. A TDML specifies the maximum amount of a pollutant that a waterbody can receive and still meet these standards. Furthermore, a TMDL identifies the sum of the allowable loads of a single pollutant from all point and non-point sources and determines a margin of safety to ensure that the waterbody can be protected in case there are unknown pollutant sources or unforeseen events which may impair water quality. Ecology initiated a TMDL for fecal coliform bacteria in North Creek and published a draft report in 2001 (Ecology 2001). Sources of the fecal coliform bacteria include agriculture, septic systems, and urban development (Ecology 2001).

Washington State Water Quality Assessment 305(b) Report

The CWA, section 305(b), requires states to submit a water quality assessment to the U.S. EPA on the status of their waterbodies (surface and ground) every two years. The 2000 Washington State Water Quality Assessment completed by Ecology (2000) is a summary of the two previous assessments completed in 1996 and 1998 and does not contain new or updated information. The 1996 and 1998 assessments generally characterize state waters where individual waterbody segment impairments are not addressed or identified. However, the 1994 assessment identifies individual waterbody segments and their impaired uses and is used to describe stream basin impairments discussed in the following sections of this report.

Stormwater General NPDES Permit

Section 402 (p) of the CWA requires a stormwater permit for construction activities greater than 1 acre in size that have a discharge to a surface water or a storm drain system which, in turn, discharges to a surface water. Surface waters include wetlands, ditches, streams, rivers, marine waters and estuaries (Ecology 1999). A permit is not required, if all the stormwater from a single project can be retained and infiltrated on-site via dry wells, infiltration basins, or other approved means of disposal (Ecology 1999).

A Notice of Intent (NOI) must be filed with Ecology for the clearing, grading and excavation of new construction sites five acres or larger in size as part of the state's General Stormwater Permit. The NOI requires the publication of a public notice once a week for two consecutive weeks in a newspaper with local coverage in the area of construction. Ecology must receive a copy of the NOI and approve a draft copy of the public notice prior to this publication. A 30-day public comment period follows the date of the second public notice publication. Ecology grants permit coverage no sooner than 31 days following the date of publication of the second public notice.

Existing Water Quality: Treatment Plant Sites

Unocal Site

Willow Creek

Willow Creek, which originates in the City of Edmonds near 6th Avenue and Elm Street, flows northwest through a moderately incised ravine that is surrounded by residential and commercial development, then underneath Pine Street near SR 104 and past Deer Creek Fish Hatchery before flowing into Edmonds Marsh. The stream is approximately 0.75 mile in length. Willow Creek is considered a Class AA surface water by Ecology because it drains to Puget Sound, which is also classified a Class AA water body (Ecology 1997a).

Water quality samples were collected in Willow Creek in June and July 1996 as part of a study supporting the Edmonds Crossing EIS (Edmonds 2001). Water quality was good, with overall quality similar to the water quality found in other Seattle metropolitan streams (Edmonds 2001). Sampling indicates that, however, pH, dissolved oxygen, fecal coliform bacteria, and temperature do not always meet applicable Class AA criteria (Edmonds 2001). The low pH and low dissolved oxygen concentrations could potentially harm aquatic biota (Edmonds 2001). Low pH values measured in Willow Creek may be the result of natural soil and geologic factors in the watershed. The low dissolved oxygen concentrations measured in the vicinity of Edmonds March could be attributed to oxygen depletion in the warm and shallow waters of the Marsh.

Samples collected near the Deer Creek Fish Hatchery had elevated concentrations of nutrients, suspended solids, fecal coliform bacteria, and metals during storm sampling (Edmonds 2001). Water temperatures exceeding the Class AA criterion of 16 °C, were measured in an open area created by Edmonds Marsh and a ditch just upstream from the sampling station. Willow Creek water quality in the downstream reaches is strongly influenced by tidal influxes of saltwater.

Willow Creek Field Reconnaissance Summary

During a field reconnaissance survey of Willow Creek and the Unocal site on May 14, 2002, water quality and quantity measurements were collected at three locations. The sampling locations were the same as those obtained in Willow Creek during June and July 1996 as part of the study supporting the Edmonds Crossing EIS (Edmonds 2001). Additional field measurements were collected in the Edmonds storm drain located below the tide gate. Flow, turbidity, pH, conductivity, and temperature were measured. Flow measurements were estimated by measuring the width, average depth, and timing a floating object. Other *in-situ* variables were measured with field meters that were calibrated using standard operating procedures. Results summarized in Table 3 below indicate relatively low flow rates ranging from 0.5 to 1.7 cfs, low turbidities, with pH and temperature ranges within acceptable Washington State Class AA water quality standards. These sampling results are consistent with a relatively cool, wet spring.

Table 3. Water Quality Monitoring Stations

Sampling Station	Time	Flow (cfs)	Turbidity (ntu)	pH	Conductivity (µmhos/com)	Temperature (°C)
WQM-1	1025	1.72	2.46	7.1	413	10.0
WQM-2	1115	----	1.96	6.8	269	10.0
WQM-3	1150	0.83	1.84	7.4	293	10.0
Edmonds Storm Drain	1050	0.54	38.5	7.1	519	12.0

WQM-1 = Water quality monitoring location #1

Route 9 Site

Little Bear Creek Basin

Little Bear Creek originates north of the City of Everett in unincorporated Snohomish County and flows south through the City of Woodinville and into the Sammamish River at River Mile (RM) 5.4. Little Bear Creek is designated a Class AA (extraordinary) surface water by Ecology (Ecology 1997a). The mainstem of the stream is 7.7 miles in length. The Little Bear Creek drainage basin is approximately 15 square miles in size and consists of a total of approximately 26 miles of stream including tributary streams (Snohomish County 2002a). Major tributary streams include Trout Stream, Cutthroat Creek, and Rowlands Creek.

On Ecology's 1996 and 1998 303(d) water quality limited lists, the stream (Segment Id No. WA-08-1085, mouth to RM 7.7) is listed for fecal coliform bacteria (Ecology 1996; Ecology 1998). The sources of these bacteria are pet and livestock waste and failing septic systems (Snohomish County 2002b). The highest concentrations are found in the upper mainstem of the stream (Snohomish County 2002a). However, no TMDL study or basin action plan has been initiated by Ecology to address these fecal coliform bacteria exceedances.

In Ecology's 1994 305(b) assessment (Ecology 1995), Little Bear Creek (Segment Id. No.: WA-08-1085) is identified as supporting the following uses: rearing, harvesting and other fish spawning; salmonid spawning; and salmonid and other fish migration. This segment is impaired for primary and secondary contact recreation, with impairment sources cited as pasture land, land development, and urban runoff/storm sewers. The assessment identified the causes of impairment as ammonia, pH, dissolved oxygen/organic enrichment, and fecal coliform bacteria/other pathogen indicators.

Water Quality

Long-term water quality samples have been collected by Snohomish County at two mainstem sites and by King County at one site located near the stream's mouth. The locations and duration of water quality monitoring (baseline and storm) are listed in Table 4.

Table 4. King County and Snohomish County long-term Little Bear Creek surface water quality sampling stations and duration of sampling.

Sampling Location	Water Quality Sampling Record Evaluated	Agency	Frequency of Sampling
51st Street SE (Upstream Station LBLU)	1993-1999[a]	Snohomish County	Monthly
228th Street (Downstream Station LBLD)	1993-1999[a]	Snohomish County	Monthly
Near Mouth (Site 0478)	1979-1999[b]	King County	Monthly
Near Mouth (Site 0478)	1987-2000[b]	King County	Storm[c]

Source: Snohomish County (2002b) and King County (2002a)

[a] Snohomish County no longer collects baseline water samples at this station. Results in the following discussion are summarized for the water quality sampling record shown.

[b] King County continues to collect water quality data at this station; however; results are only available for the water quality sampling record shown.

[c] King County collects storm flow samples at this station three to six times annually. Trace metals samples reported were collected from 1995 through 2000.

Snohomish County's long-term monitoring stations were located along the upper mainstem (51st Street SE) and lower mainstem (228th Street SE) (Tables 5 and 6). Data were collected at both stations from 1993 through 1999. During sampling, the waters of Little Bear Creek were generally cool, with a neutral pH, some turbidity, moderate total suspended solids concentrations and high fecal coliform concentrations. Based on this data, stream water quality can be characterized as fair to good. Sampling indicated that pH, dissolved oxygen, and fecal coliform bacteria did not meet applicable Class AA criteria. One temperature measurement at the upper station exceeded the 16.0°C Class AA criterion. The upper station also had more violations of Class AA standards for fecal coliform bacteria, pH, and dissolved oxygen. Fecal coliform bacteria concentrations were also higher at the upper station, indicating the presence of more septic systems and/or pet and livestock populations. Dissolved oxygen concentrations did not meet the minimum Class AA criterion of 9.5 mg/L 25 percent of the time at the upper station, compared to 8 percent at the lower station.

Table 5. Summary of Little Bear Creek ambient water quality data collected by Snohomish County from 1993 through 1999 at 51st Street SE (Upstream Station LBLU).

Parameter	Number of Samples	Mean	Minimum	Maximum	Class AA Standards	Class AA Violations	Percent Not Meeting Standard
Staff depth (feet)	69	2.11	-0.08	3.07	N/A	N/A	N/A
Temperature (°C)	72	9.3	1.7	16.1	16.0	1	1
Dissolved oxygen (mg/L)	72	10.3	6.56	13.8	9.5	18	25
pH (standard units)	71	7.1	6	7.8	6.5-8.5	5	7
Conductivity (μmhos/cm)	68	103	29.3	145	N/A	N/A	N/A
Turbidity (NTU)	21	3.51	0.91	17.3	N/A[a]	N/A[a]	N/A[a]
Fecal coliform bacteria (CFU/100mL)	70	512	2	5,800	50[b]	65[b]	93[b]
Hardness (mg CaCO3/L)	20	46.3	32	66	N/A	N/A	N/A
Nitrate–nitrite nitrogen (mg/L)	72	1.28	0.16	2.4	N/A	N/A	N/A
Total phosphorus (mg/L)	72	0.053	0.022	0.267	N/A	N/A	N/A
Total copper (μg/L)	72	1.48	0.02	9.2	8.22[c]	1[c]	1[c]
Total lead (μg/L)	71	1.24	0.01	28	27.6[c]	None[c]	0[c]
Total zinc (μg/L)	60	4.34	0.19	16	59.5[c]	None[c]	0[c]
Total suspended solids (mg/L)	60	8.9	1	140	N/A	N/A	N/A

Source: Snohomish County (2002b)

N/A = Not Applicable, no applicable surface water quality standard exists (Chapter 173-201AWAC).

[a] The turbidity standard is based on comparison of values for locations upstream (background) and downstream of turbidity sources. The application of the standard to only one location on a stream is not appropriate (N/A).

[b] The fecal coliform bacteria standard is based on a geometric mean value (Chapter 173-201AWAC), but individual sample values were compared to this standard for determining the number and percent of non-standard values.

[c] Metals standards include acute and chronic standards that are based on dissolved metals and depend on hardness. Metals standards shown are acute standards for dissolved metals at the mean hardness value. Total metals were converted to dissolved metals using conversion factors in Chapter 173-201A WAC and compared to the acute standard using the hardness value measured during sampling, or using the mean hardness value for this station if the sample hardness was not available.

Table 6. Summary of Little Bear Creek ambient water quality data collected by Snohomish County from 1993 through 1999 at 228th Street SE (Station LBLD).

Parameter	Number of Samples	Mean	Minimum	Maximum	Class AA Standards	Class AA Violations	Percent Not Meeting Standards
Staff depth (feet)	70	0.68	-1.33	1.38	N/A	N/A	N/A
Temperature (°C)	72	9.72	1.9	17	16.0	None	None
Dissolved oxygen (mg/L)	72	10.9	6.7	14.1	9.5	6	8
pH (standard units)	71	7.23	6.34	8	6.5-8.5	2	3
Conductivity (μmhos/cm)	68	107	24.8	153	N/A	N/A	N/A
Turbidity (NTU)	21	3.83	1.29	23.7	N/A[a]	N/A[a]	N/A[a]
Fecal coliform bacteria (CFU/100 mL)	68	434	14	2,300	50[b]	63[b]	93[b]
Hardness (mg CaCO3/L)	20	47.1	34	57	N/A	N/A	N/A
Nitrate - nitrite nitrogen (mg/L)	71	0.936	0.093	2	N/A	N/A	N/A
Total phosphorus (mg/L)	72	0.05	0.003	0.099	N/A	N/A	N/A
Total copper (μg/L)	72	1.40	0.08	7	8.37[c]	None[c]	0[c]
Total lead (μg/L)	69	0.83	0.08	5.4	28.2[c]	None[c]	0[c]
Total zinc (μg/L)	60	5.48	1.31	29	60.5[c]	None[c]	0[c]
Total suspended solids (mg/L)	66	7.39	1	49	N/A	N/A	N/A

Source: Snohomish County (2002b)

N/A = Not Applicable, no applicable surface water quality standard exists (Chapter 173-201A WAC).

[a] The turbidity standard is based on comparison of values for locations upstream (background) and downstream of turbidity sources. The application of the standard to only one location on a stream is not appropriate (N/A).

[b] The fecal coliform bacteria standard is based on a geometric mean value (Chapter 173-201A WAC), but individual sample values were compared to this standard for determining the number and percent of non-standard values.

[c] Metals standards include acute and chronic standards that are based on dissolved metals and depend on hardness. Metals standards shown are acute standards for dissolved metals at the mean hardness value. Total metals were converted to dissolved metals using conversion factors in Chapter 173-201A WAC and compared to the acute standard using the hardness value measured during sampling, or using the mean hardness value for this station if the sample hardness was not available.

Total copper, lead, and zinc were measured during baseline sampling events. Overall, total metals concentrations were low. The mean total lead concentration was slightly higher at the upper station (1.24 μg/L) than the mean measured at the lower station (0.83 μg/L). At both stations, total lead and zinc did not exceed their respective acute toxicity standards (Ecology 1997a). Total copper concentrations, after conversion to the dissolved fraction, exceeded the acute standard once during sampling at the lower station (51st Street SE).

Total phosphorus and nitrate-nitrite nitrogen concentrations were slightly higher in samples collected at the upstream station (51st Street SE) than the downstream station (228th Street SE). During sampling, the mean upstream nitrate-nitrite nitrogen concentration was 1.28 mg/L compared to 0.936 mg/L at the lower station. The upstream mean total phosphorus concentration was 0.053 mg/L compared to 0.050 mg/L at the lower station. These higher nutrient concentrations may be related to more septic system use and the presence of livestock in the upper basin.

King County collects monthly water quality samples in Bear Creek near its mouth at the Sammamish River (Site 0478) (Table 7). Based on sampling from 1979 through 1999, water quality results are similar to those described above for Snohomish County's long-term water quality stations. Stream waters are generally cool, neutral with some turbidity, and relatively high in total suspended solids concentration. The water quality is degraded due to high concentrations of fecal coliform bacteria. The mean total suspended solids concentration during baseline sampling was moderately high, 10.29 mg/L. Fecal coliform bacteria and enterococcus were detected during all sampling events. Sampling indicates fecal coliform bacteria exceed the Class AA criterion 77 percent of the time.

The mean total phosphorus concentration measured at the mouth was 0.068 mg/L, which is greater than the mean concentrations measured upstream at both Snohomish County stations. The nitrate nitrogen concentration measured by King County at the mouth is identical to the mean measured by Snohomish County at the downstream station (228th Street SE), 0.093 mg/L.

Based on the long-term monitoring at this station by King County, the data exhibit a decreasing trend in fecal coliform bacteria concentrations and an increasing trend in temperature and conductivity (King County 2002a). The basin has undergone an increase in urbanization over the last 20 years, which could have contributed to the relatively high total suspended solids concentrations measured at this station (King County 2002a). Temperature increases could be attributed to climatic changes, removal of riparian vegetation, or some other long-term trend; however, the specific cause has not been determined (King County 2002a).

Table 7. Summary of Little Bear Creek ambient water quality data collected by King County from 1979 through 1999 (Site 0478).

Parameter	Number of Samples	Mean	Minimum	Maximum	Class AA Standards	Number Non-Standard	Percent Non-Standard
Flow (cfs)	190	19.7	2.68	260	N/A	N/A	N/A
Dissolved oxygen (mg/L)	234	11.0	7.3	14.1	9.5	6	3
Temperature (°C)	252	9.56	0.1	17.5	16.0	3	1
Turbidity (NTU)	241	4.61	0.3	50	N/A[a]	N/A[a]	N/A[a]
pH (standard units)	238	7.32	6.08	8.42	6.5 – 8.5	1	0
Conductivity (μmhos/cm)	241	124	55	180	N/A	N/A	N/A
Total suspended solids (mg/L)	241	10.3	0.67	194	N/A	N/A	N/A
Ortho-phosphorus (mg/L)	240	0.034	0.003	0.19	N/A	N/A	N/A
Total phosphorus (mg/L)	240	0.068	0.026	0.57	N/A	N/A	N/A
Ammonia nitrogen (mg/L)	217	0.03	0.001	0.024	N/A[b]	N/A[b]	N/A[b]
Nitrate nitrogen (mg/L)	239	0.923	0.229	2.5	N/A	N/A	N/A
Total nitrogen (mg/L)	84	1.28	0.727	2.32	N/A	N/A	N/A
Enterococcus (CFU/100 mL)	135	160	13	4,400	N/A	N/A	N/A
Fecal coliform bacteria (CFU/100 mL)	243	207	9	13,000	50[c]	187[c]	77[c]

Source: King County (2002a)

N/A = Not Applicable, no applicable surface water quality standard exists (Chapter 173-201A WAC).

[a] The turbidity standard is based on comparison of values for locations upstream (background) and downstream of turbidity sources. The application of the standard to only one location on a stream is not appropriate (N/A).

[b] The ammonia standard includes acute and chronic criteria that vary depending on pH, temperature, and the presence of salmonids. Assuming salmonids are present at typical worst-case conditions of high temperature (16°C) and high pH (8.0), acute and chronic criteria are 5.6 and 1.0 mg/L as nitrogen, respectively. The ammonia standard was not applied to the sample values.

[c] The fecal coliform bacteria standard is based on a geometric mean value (Chapter 173-201A WAC), but individual sample values were compared to this standard for determining the number and percent of non-standard values.

King County collects storm flow samples in Little Bear Creek at the same location as ambient sampling, near the stream's mouth at the Sammamish River (Site 0478) (Table 8). Based on samples collected from 1987 through 2000 during storms, the waters of Little Bear Creek are cool, well oxygenated, with a neutral pH, but degraded because of high turbidity, high total suspended solids and high fecal coliform bacteria concentrations. Sampling indicates that fecal coliform bacteria concentrations do not meet Class AA criteria during storms. Sporadic dissolved oxygen measurements do not meet the minimum Class AA criterion of 9.5 mg/L. Based on these results, the water quality of Little Bear Creek during storm events is characterized as fair to good. Sampling indicates fecal coliform bacteria levels do not meet the Class AA criterion 100 percent of the time during storms. The mean turbidity during storm sampling was high, 19.0 NTU, exceeding the Class AA criterion 68 percent of the time. Total phosphorus is high during sampling with a mean total phosphorus concentration of 0.169 mg/L. During storms, the mean nitrate nitrogen concentration is 0.871 mg/L. Metals data were collected by King County at this station during storm events. During storm sampling, Little Bear Creek met applicable metals criteria for arsenic, lead, mercury, silver and zinc (King County, 2002a). Nickel and copper exceeded the standards four and nine times, respectively (King County 2002a). Cadmium met the standard during four sampling events; however, compliance with the remaining samples is undetermined because the standards are below the analytical detection limit (King County 2002a).

When comparing King County storm event results versus ambient results for Little Bear Creek, the mean turbidity, total suspended solids, total phosphorus, total nitrogen, ammonia, and fecal coliform bacteria concentrations are higher during storms than those measured during monthly sampling. The mean water temperature and dissolved oxygen concentrations are essentially equal to the means measured during ambient sampling. The nitrate nitrogen concentrations are slightly higher during ambient sampling (mean of 0.923 mg/L) than measured during storms (mean of 0.871 mg/L), suggesting a baseflow component, which is diluted during storm events (King County 2002b). Total phosphorus concentrations are almost double during storms than during ambient conditions. Phosphorus readily binds to particulate matter and, because during storms the amount of suspended material present is much higher than during ambient conditions, the total phosphorus concentration is also higher (King County 2002b).

Stream Discharge

Discharge was measured by King County during baseline sampling from 1979 through 1999. Discharge ranged from 2.68 cfs to 260 cfs, with a mean discharge of 19.69 cfs (King County 2002a). Snohomish County collects discharge in Little Bear Creek at 228th Street. Based on discharge measured from March 2000 through March 2002 (12 measurements), the average dry season discharge (June through September) was 21.4 cfs and the average wet season (October through May) was 24.1 cfs (Smith, M., personal communication, May 20, 2002).

Table 8. Summary of Little Bear Creek storm water quality data collected by King County from 1987 through 2000 (Site 0478).

Parameter	Number of Samples	Mean	Minimum	Maximum	Class AA Standards	Number Non-Standard	Percent Non-Standard
Flow (cfs)	1	130	130	130	N/A	N/A	N/A
Dissolved oxygen (mg/L)	27	11	9	14	9.5	2	7
Temperature (°C)	28	9.7	4.0	15.8	16.0	0	0
Turbidity (NTU)	28	19.0	3.7	91.0	N/A[a]	N/A[a]	N/A[a]
pH (standard units)	28	7.1	6.5	8.1	6.5 – 8.5	0	0
Conductivity (μmhos/cm)	28	108	69.2	165	N/A	N/A	N/A
Total suspended solids (mg/L)	28	46.9	7.4	158	N/A	N/A	N/A
Ortho-phosphorus (mg/L)	28	0.038	0.015	0.162	N/A	N/A	N/A
Total phosphorus (mg/L)	28	0.169	0.045	0.396	N/A	N/A	N/A
Ammonia nitrogen (mg/L)	27	0.041	0.012	0.110	N/A[b]	N/A[b]	N/A[b]
Nitrate nitrogen (mg/L)	28	0.871	0.480	2.30	N/A	N/A	N/A
Total nitrogen (mg/L)	23	1.51	0.935	2.90	N/A	N/A	N/A
Enterococcus (CFU/100 mL)	28	1,650	280	24,000	N/A	N/A	N/A
Fecal coliform bacteria (CFU/100 mL)	28	1,020	150	13,000	50[c]	28[c]	100[c]

Source: King County (2002a)

N/A = Not Applicable, no surface water quality standard exists (Chapter 173-201A WAC).

[a] The turbidity standard is based on comparison of values for locations upstream (background) and downstream of turbidity sources. The application of the standard to only one location on a stream is not appropriate (N/A).

[b] The ammonia standard includes acute and chronic criteria that vary depending on pH, temperature, and the presence of salmonids. Assuming salmonids are present at typical worst-case conditions of high temperature (16°C) and high pH (8.0), acute and chronic criteria are 5.6 and 1.0 mg/L as nitrogen, respectively. The ammonia standard was not applied to the sample values.

[c] The fecal coliform bacteria standard is based on a geometric mean value (Chapter 173-201A WAC), but individual sample values were compared to this standard for determining the number and percent of non-standard values.

Sediment Data

Sediment data were collected by King County at the mouth of Little Bear Creek annually from 1995 through 2000 and analyzed for selected metals (Table 9). During sampling, arsenic, silver and mercury were not detected and cadmium, copper, lead, nickel, and zinc were detected at least once. Sampling indicates sediment quality is good, with metals concentrations that do not exceed applicable sediment thresholds (Ecology 1997b).

Table 9. Little Bear Creek sediment data collected by King County near the mouth (Site 0478).

Stream Sediment Metal Concentrations (mg/kg dry weight)			
	Sediment Threshold (Ecology 1997b)	Mean	Minimum – Maximum
Arsenic	None	< 0.05[a]	< 0.05[a]
Silver	None	< 0.004[a]	< 0.004[a]
Mercury	2	< 0.0002[a]	< 0.0002[a]
Cadmium	10	<0.002[a]	< 0.002[a] – 0.16
Copper	110	5.0	4.6 – 5.4
Lead	250	3.0	1.8 – 4.4
Nickel	75	16.3	10.8 – 18.0
Zinc	820	29.3	24.9 – 32.3

Source: King County (2002a)
[a] Detection limit

Pesticides

As part of the Sammamish/Washington Analysis and Modeling Program (SWAMP), King County conducted the Small Streams Toxicity Study to investigate the possible biological implications associated with the presence of pesticides in selected small urban streams and one control stream (King County 2002c). Little Bear Creek was one of the urban streams included in the 2000 study. Streams were tested for toxicity, pesticides, and metals during four sampling events (two spring storms, a summer baseflow event, and one fall storm). During the 2000 study, some of the pesticides most frequently detected during storm events included the insecticide diazinon, the herbicides 2,4-D, dichlobenil, MCPP, prometon, and trichlopyr, and the insecticide/fungicide pentachlorophenol (King County 2002c). In general, the study detected fewer pesticides during baseline sampling than during storm events (King County 2002c). Sampling results indicate that 15 pesticides were detected in Little Bear Creek during 2000. Eleven metals were detected during sampling; however, all but aluminum were measured at concentrations not harmful to aquatic communities (King County 2002c).

Toxicity was observed in all unfiltered samples (3 storms and 1 baseflow) for green algae (*Selenastrum capricornutum*). However, filtering of the samples removed the observed toxicity,

suggesting the toxicant(s) were associated with particulates in the sample (King County 2002d). Toxicity was observed for aquatic vascular plants (*Lemna minor*) in the June 2000 baseflow unfiltered sample. Only unfiltered samples were analyzed for *Lemna minor*. Toxicity was not observed for the water flea (*Ceriodaphnia dubia*) in all samples (filtered and unfiltered).

Benthic Macroinvertebrate Summary

Sampling of benthic macroinvertebrates has been conducted in Little Bear Creek by Snohomish County and the University of Washington. An Index of Biological Integrity, or IBI, was calculated from the sampling results (Table 10).

Table 10. Benthic Macroinvertebrates Sampling Results

Site Location	Sampler	Date	B-IBI
SE 228th Street and Highway #9, straight east of Stone Yard	Kleindl/Morely Snohomish Co SWM/ and UW	1994	16
SE 228th Street and Highway #9, straight east of Stone Yard	Kleindl/Morely Snohomish Co SWM/ and UW	1997	28
SE 228th Street and Highway #9, straight east of Stone Yard	Kleindl/Morely Snohomish Co SWM/ and UW	1997	30
SE 228th Street and Highway #9, straight east of Stone Yard	Kleindl/Morely Snohomish Co SWM/ and UW	1999	28
SE 228th Street and Highway #9, straight east of Stone Yard	Kleindl/Morely Snohomish Co SWM/ and UW	2000	30

Source: Snohomish County email, June 2002.

An index of biological integrity is a synthesis of diverse biological information, which numerically depicts associations between human influence and biological attributes. It is composed of several biological attributes or 'metrics' that are sensitive to changes in biological integrity caused by human activities. Multi-metric biological indexes include the following benthic macroinvertebrate information:

- Pollution tolerance/intolerance taxa;
- Taxonomic composition (number and abundance of taxa); and
- Population attributes (e.g., number of predators).

Biological integrity has been defined as " the ability to support and maintain a balanced, integrated adaptive assemblage of organisms having species composition, diversity, and functional organization comparable to that of natural habitat of the region" (Karr and Dudley 1981; Karr et al. 1986).

Existing Water Quality: Conveyance Corridors

Introduction

This section describes existing characteristics and conditions of water resources located in the vicinity of the proposed conveyance corridors from approximately the City of Woodinville west to Puget Sound near the City of Edmonds. The proposed conveyance corridors would extend approximately 12 miles east to west. Major waterbodies in the vicinity are the Sammamish River, Lake Washington, Puget Sound, and their tributaries, which include North Creek, Swamp Creek, Lyon Creek, McAleer Creek and Willow Creek. Other water resources in the area include Lake Ballinger, its major inflow Hall Creek, and its source Hall Lake. Willow Creek and Little Bear Creek are discussed under Existing Water Quality: Treatment Plants, above.

In the following sections, the hydrologic setting and water quality conditions described for streams and lakes the Cedar-Sammamish River basin are based primarily on available information and data obtained from King County, Snohomish County, and Ecology.

Regulatory Environment

Applicable stormwater regulations and associated manuals along the conveyance corridors would vary based on local jurisdiction. The stormwater regulatory manuals and codes that would apply to the Brightwater project are summarized in Table 11.

Hydrologic Setting

The proposed conveyance corridors are located within the Cedar-Sammamish drainage basin (Water Resource Inventory Area [WRIA] 8) in King and Snohomish County. The watershed originates in the upper Cedar River basin in the western Cascade foothills of King County. The upper Cedar River flows into Chester Morse Lake. Drinking water for the City of Seattle is diverted at Landsburg Dam, downstream of Chester Morse Lake. From the Lake, the Cedar River flows approximately 56 miles north and west into the south end of Lake Washington at Renton. Lake Washington drains into Puget Sound via the Lake Washington Ship Canal, which was dredged in 1916 to provide navigation from Puget Sound to Lake Washington, connecting through Lake Union. The Cedar River originally flowed into the Black River, a tributary to the Duwamish River, but was diverted to Lake Washington as part of the ship canal project to improve lake circulation and flushing (WDFW 1975). The Duwamish River flows into the Puget Sound near west Seattle.

The Cedar-Sammamish basin is 692 square miles in size and consists of forest (45 percent), urban (38 percent), agriculture (1 percent), and rangeland (<1 percent) (Ecology 1995). The basin lies within the Puget Sound lowlands (86 percent) and Cascade (14 percent) eco-regions. The basin's average annual precipitation is 50 inches per year (Ecology 1995).

Table 11. Stormwater manuals used by jurisdictions at proposed portal sites.

Jurisdiction	Applicable Stormwater Manual	Proposed Corridor (Portal Site)
City of Bothell	King County Stormwater Manual (1998)	Unocal (13, 14) Route 9 – Influent (41) Route 9 – 228th Street (37, 39) Route 9 – 195th Street (41)
City of Brier	Ecology Stormwater Management Manual (2001)	Route 9 – 228th Street (30, 33)
City of Edmonds	Ecology Stormwater Management Manual (1992), Edmonds Development Code, ECC 18-30 (1995)	Unocal (1) Route 9 – 228th Street (1, 24) Route 9 – 195th Street (23, 27)
City of Kenmore	King County Stormwater Manual (1998)	Unocal (11, 12) Route 9 – Influent (11, 34) Route 9 – 195th Street (45, 44)
City of Lake Forest Park	King County Surface Water Manual (1998)	Unocal (7, 10) Route 9 – 195th Street (7)
City of Mountlake Terrace	Ecology Stormwater Management Manual (2001) [a]	Unocal (5, 7) Route 9 – 228th Street (26) Route 9 – 195th Street (7)
City of Shoreline	King County Surface Water Manual (1998)	Route 9 – 195th Street (27)
Snohomish County	Snohomish County Drainage Manual (1998)	Route 9 – 228th Street (33)
Town of Woodway	Ecology Stormwater Management Manual (1992)	Unocal (1) Route 9 – 228th Street (1) Route 9 – 195th Street (19)

[a] By administrative action, the City of Mountlake Terrace is using Ecology's 2001 manual, although the City has only formally adopted Ecology's 1992 manual.

Surface Water Quality Basin Descriptions

The proposed project would have conveyance corridors that cross through a combination of the following major surface water basins within WRIA 8 (identified east to west): Little Bear Creek basin, North Creek basin, Swamp Creek basin, Lyon Creek basin, McAleer Creek basin, and the Puget Sound basin. Existing information about these basins is presented below followed by descriptions of the Sammamish River and Lake Washington. Little Bear Creek and Willow Creek (Puget Sound basin) are discussed under Existing Water Quality: Treatment Plant Sites.

North Creek Basin

North Creek originates in the City of Everett near the Everett Mall and flows south through the City of Bothell, the City of Mill Creek, and unincorporated Snohomish County and flows into the Sammamish River at RM 4.4. North Creek is designated a Class AA (extraordinary) surface water by Ecology (1997a). North Creek's headwaters are located at an elevation of 180 feet.

The stream drains a narrow floodplain in the upper reaches then widens to a broad, flat floodplain near its confluence with the Sammamish River at 25 feet elevation.

The mainstem of the stream is 12.6 miles in length. The drainage basin is approximately 19,000 acres with 49 percent of the watershed consisting of impervious surface from urban land uses (King County 2002b). General land use zoning is 39 percent suburban family, 30 percent rural or low-density residential, 24 percent site-sensitive area, and 3 percent urban residential. The remaining 4 percent is divided among commercial, industrial, utility, and community facilities (Ecology 2001). The basin includes Silver Lake, Ruggs Lake, and Thomas Lake. Major tributary streams include Penny Creek and Silver Creek/Tambark Creeks.

On Ecology's 1996 303(d) water quality limited list, North Creek (Segment Id No. WA-08-1065, mouth to RM 12.6) is listed for fecal coliform bacteria (Ecology 1996). On the 1998 303(d) list, dissolved oxygen was added as a parameter not meeting the applicable water quality standards (Ecology 1998a). Silver Lake (Segment Id No. WA-08-9300) is listed for total phosphorus on the 1996 and 1998 303(d) water quality limited lists (Ecology 1996; Ecology 1998).

Because of fecal coliform bacteria impairment, a TMDL study was completed by Ecology for the North Creek watershed (Ecology 2001) with the draft TMDL submittal report published in April 2002 (Ecology 2002a). The major sources of fecal coliform bacteria include agriculture, on-site disposal (septic) systems, and urban development (Ecology 2001). Dry season fecal coliform concentrations in North Creek are actually higher than the wet season (November through May), suggesting a continuous pollutant-loading source (Ecology 2001). Wet season concentrations are also high, suggesting a strong storm component (Ecology 2001). Because of the diffuse sources, the TMDL plan recommends increasing flows during the dry season to dilute fecal coliform bacteria concentrations and target lowering non-point source concentrations in the runoff (Ecology 2001). Stream flow attenuation could be achieved by using detention ponds, establishing or restoring wetlands, and managing riparian corridors (Ecology 2001). Ecology's TMDL strategy initially focuses on fecal coliform bacteria, recognizing that fecal coliform sources are also typically sources that affect dissolved oxygen concentrations (Ecology 2001).

In Ecology's 1994 305(b) assessment (Ecology 1995), North Creek (Segment Id. No.: 08-1065) is identified as supporting the following uses: rearing, harvesting and other fish spawning; salmonid spawning; and salmonid other fish migration. This segment is impaired for primary and secondary contact recreation with impairment sources cited as pasture land, land development, urban runoff/storm sewers, on-site wastewater systems (septic tanks), channelization, removal of riparian vegetation, and streambank modification/destabilization. The assessment identified the cause of the impairments as fecal coliform bacteria and/or other pathogen indicators.

Water Quality

King and Snohomish Counties collect water quality samples in the mainstem of North Creek at two long-term monitoring stations. The locations and duration of water quality monitoring are listed in Table 12.

Table 12. Summary of King County and Snohomish County long-term North Creek surface water quality monitoring stations and duration of sampling.

Sampling Location	Water Quality Sampling Record Evaluated	Agency	Frequency of Sampling
Upstream Side of Freeway Bridge (Site 0474)	1979-1999[a]	King County	Monthly
Upstream Side of Freeway Bridge (Site 0474)	1987-2000[a]	King County	Storm[b]
McCollum Park (Upstream Station NCLU)	1992-2002	Snohomish County	Monthly

Source: King County (2002a,b) and Snohomish County (2002b).

[a] King County continues to collect water quality data at this station; however; results are only available for the water quality sampling record indicated.

[b] King County collects storm flow samples at this station three to six times annually. Trace metals samples reported were collected from 1995 through 2000.

King County collects ambient water quality samples monthly at the mouth of North Creek on the upstream side of the I-405/SR-522 freeway bridge (Site 0474) near the mouth (Table 13). Based on data collected from 1979 through 1999, the waters of North Creek are generally cool, slightly turbid, and well oxygenated with high fecal coliform bacteria concentrations and moderate total suspended solids concentrations. The stream's water quality has been generally characterized as good by King County (Metro 1989; 1990; 1991; and 1994).

During sampling, sporadic measurements of temperature and pH did not meet applicable Class AA criteria. Sampling indicates dissolved oxygen does not meet the minimum Class AA criterion 7 percent of the time; however, the mean concentration measured during sampling, 10.84 mg/L, exceeds the minimum Class AA criterion. Fecal coliform bacteria do not meet the Class AA criterion 73 percent of the time. Fecal coliform bacteria are present in the stream at relatively high concentrations with a mean of 248 CFU/100 mL measured during baseline sampling.

The North Creek total phosphorus concentration is high, with a mean of 0.089 mg/L measured by King County over the 20-year period. The mean nitrate nitrogen concentration was moderately high, 0.087 mg/L; however, this concentration is within the range recorded for other urban streams measured during baseline sampling (King County 2002a). Sources of nitrate include residential fertilizer use and livestock waste (King County 2002d). The mean ammonia concentration is slightly elevated, with a mean concentration of 0.0375 mg/L.

Based on the long-term monitoring at this station by King County, the total phosphorus, ortho-phosphorus, and fecal coliform concentrations have actually decreased, whereas temperature and conductivity have increased over time (King County 2002a). The reduction in phosphorus may be the result of implementation of best management practices in the basin (King County 2002a). The reduction in fecal coliform bacteria may be the result of land use changes as hobby and commercial farms and livestock related activities have been replaced with other land uses (King County 2002a). Temperature increases could be attributed to climatic changes, removal of

riparian vegetation, or some other long-term trend; however, the specific cause has not determined (King County 2002a).

Table 13. Summary of North Creek water quality data collected by King County from 1979 through 1999 (Site 0474).

Parameter	Number of Samples	Mean	Minimum	Maximum	Class AA Standards	Number Non-Standard	Percent Non-Standard
Flow (cfs)	175	38.4	1.3	300	N/A	N/A	N/A
Dissolved oxygen (mg/L)	231	10.8	7.3	14.02	9.5	16	7.10
Temperature (°C)	245	9.98	0.1	20	16.0	17	6.94
Turbidity (NTU)	234	3.89	0.2	30	N/A[a]	N/A[a]	N/A[a]
pH (standard units)	231	7.35	6.09	8.4	6.5 – 8.5	1	0.43
Conductivity (μmhos/cm)	234	153	61	570	N/A	N/A	N/A
Total suspended solids (mg/L)	235	7.72	1.25	97.14	N/A	N/A	N/A
Ortho-phosphorus (mg/L)	233	0.051	0.007	0.23	N/A	N/A	N/A
Total phosphorus (mg/L)	233	0.089	0.039	0.373	N/A	N/A	N/A
Ammonia nitrogen (mg/L)	192	0.038	0.001	0.112	N/A[b]	N/A[b]	N/A[b]
Nitrate nitrogen (mg/L)	232	0.870	0.001	1.89	N/A	N/A	N/A
Total nitrogen (mg/L)	76	1.29	0.935	2.07	N/A	N/A	N/A
Enterococcus (CFU/100 mL)	127	100	10	2,600	N/A	N/A	N/A
Fecal coliform bacteria CFU/100 mL)	235	248	0	7,500	50[c]	172[c]	73.2[c]

Source: King County (2002b)

N/A = Not Applicable, no applicable surface water quality standard exists (Chapter 173-201A WAC).

[a] The turbidity standard is based on comparison of values for locations upstream (background) and downstream of turbidity sources. The application of the standard to only one location on a stream is not appropriate (N/A).

[b] The ammonia standard includes acute and chronic criteria that vary depending on pH, temperature, and the presence of salmonids. Assuming salmonids are present at typical worst-case conditions of high temperature (16°C) and high pH (8.0), acute and chronic criteria are 5.6 and 1.0 mg/L as nitrogen, respectively. The ammonia standard was not applied to the sample values.

[c] The fecal coliform bacteria standard is based on a geometric mean value (Chapter 173-201A WAC), but individual sample values were compared to this standard for determining the number and percent of non-standard values.

King County collects storm flow samples in North Creek at the same location as ambient samples, near the stream's mouth at the Sammamish River (Site 0474) (Table 14). Based on samples collected during storms from 1987 through 2000, the waters of North Creek are cool, with a neutral pH, but degraded because of moderately high turbidity, ammonia, high total suspended solids, and fecal coliform bacteria concentrations. Sampling indicates that fecal coliform bacteria concentrations do not meet Class AA criteria during storms. During sampling, one pH measurement did not meet the minimum Class AA criterion of 6.5 standard units. Dissolved oxygen does not consistently meet the Class AA minimum criterion of 9.5 mg/L; however, the mean concentration of 10.0 mg/L meets this criterion. Based on these results, the storm water quality of North Creek is characterized as fair to good. Sampling indicates fecal coliform bacteria do not meet the Class AA criterion 96 percent of the time. The mean turbidity during storm sampling is moderately high, at 9.9 NTU. The total phosphorus concentration is also moderately high during storm sampling, with a mean concentration of 0.149 mg/L. The mean nitrate-nitrite concentration is 0.740 mg/L. Metals data are also collected by King County at this station. Based on data from 1995 through 2000, North Creek metals concentrations are low, meeting applicable criteria (Ecology 1997a) (King County 2002b).

Table 14. North Creek summary of storm water quality data collected by King County from 1987 through 2000 (Site 0474).

Parameter	Number of Samples	Mean	Minimum	Maximum	Class AA Standards	Number Non-Standard	Percent Non-Standard
Flow (cfs)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dissolved oxygen (mg/L)	25	10	9	12	9.5	7	28.0
Temperature (°C)	27	9.6	4.0	14.8	16.0	0	0
Turbidity (NTU)	27	9.9	2.5	25.0	N/A[a]	N/A[a]	N/A[a]
pH (standard units)	27	7.1	6.3	8.0	6.5 – 8.5	1	3.7
Conductivity (μmhos/cm)	27	126	70.0	205	N/A	N/A	N/A
Total suspended solids (mg/L)	27	24.2	4.5	58.0	N/A	N/A	N/A
Ortho-phosphorus (mg/L)	27	0.046	0.019	0.151	N/A	N/A	N/A
Total phosphorus (mg/L)	27	0.143	0.059	0.296	N/A	N/A	N/A
Ammonia (mg/L)	21	0.051	0.016	0.140	N/A[b]	N/A[b]	N/A[b]

Parameter	Number of Samples	Mean	Minimum	Maximum	Class AA Standards	Number Non-Standard	Percent Non-Standard
Nitrate nitrogen (mg/L)	27	0.740	0.404	1.60	N/A	N/A	N/A
Total nitrogen (mg/L)	23	1.36	0.869	2.30	N/A	N/A	N/A
Enterococcus (CFU/100 mL)	26	974	160	15,000	N/A	N/A	N/A
Fecal coliform bacteria CFU/100 mL)	27	685	80	13,000	50[c]	26[c]	96.3[c]

Source: King County (2002a)

N/A = Not Applicable, no surface water quality standard exists (Chapter 173-201A WAC).

a The turbidity standard is based on comparison of values for locations upstream (background) and downstream of turbidity sources. The application of the standard to only one location on a stream is not appropriate (N/A).

[b] The ammonia standard includes acute and chronic criteria that vary depending on pH, temperature, and the presence of salmonids. Assuming salmonids are present at typical worst-case conditions of high temperature (16°C) and high pH (8.0), acute and chronic criteria are 5.6 and 1.0 mg/L as nitrogen, respectively. The ammonia standard was not applied to the sample values.

[c] The fecal coliform bacteria standard is based on a geometric mean value (Chapter 173-201A WAC), but individual sample values were compared to this standard for determining the number and percent of non-standard values.

When comparing King County storm versus ambient results for North Creek, the mean turbidity, total suspended solids, total phosphorus, total nitrogen, ammonia, and fecal coliform bacteria concentrations are higher during storms than those measured during monthly sampling. The mean baseline water temperature and dissolved oxygen concentration are essentially equal to the means measured during ambient sampling. The nitrate nitrogen concentration is slightly higher during ambient sampling (mean of 0.870 mg/L) than that measured during storms (mean of 0.740 mg/L), suggesting a baseflow component, which is diluted during storm events (King County 2002b). Total phosphorus concentrations are nearly double during storms than during ambient conditions. Phosphorus readily binds to particulate matter, and because during storms the amount of suspended material present is much higher than during ambient conditions, the total phosphorus concentration is also higher (King County 2002b).

Since May 1992, Snohomish County has collected water quality samples on a monthly basis in the upper basin at McCollum Park (Station NCLU) as part of their baseline monitoring program (Table 15). Similar to the data collected by King County (Site 0474) at the mouth, North Creek water quality is generally good, but degraded because of high fecal coliform concentrations and, in the upper basin, low dissolved oxygen concentrations.

At McCollum Park, the waters of North Creek are cool, with a neutral pH, and slightly turbid with high fecal coliform bacteria concentrations and low dissolved oxygen concentrations. Sampling indicates that dissolved oxygen does not meet the minimum Class AA criterion of 9.5 mg/l 43 percent of the time. Low dissolved oxygen generally occurs during the summer and early fall (June through October) when water temperatures are the highest. Sampling indicates fecal coliform bacteria do not meet the Class AA criterion 74 percent of the time. During

sampling, fecal coliform bacteria are present in the stream at relatively high concentrations, with a mean of 787 CFU/100 mL.

Table 15. North Creek summary of ambient water quality data collected by Snohomish County from May 1992 through March 2002 at McCollum Park (Station NCLU).

Parameter	Number of Samples	Mean	Minimum	Maximum	Class AA Standards	Class AA Violations	Percent Not Meeting Standards
Staff depth (ft)	46	4.82	1.8	8.56	N/A	N/A	N/A
Temperature (^{o}C)	115	9.68	0.2	17.3	16.0	5	4
Dissolved Oxygen (mg/L)	115	9.38	2.35	14.1	9.5	50	43
pH (standard units)	114	7.08	5.97	8.1	6.5-8.5	8	7
Conductivity (μmhos/cm)	109	130	30	370	N/A	N/A	N/A
Turbidity (NTU)	48	3.04	0.4	19.2	N/A[a]	N/A[a]	N/A[a]
Fecal coliform bacteria (CFU/100mL)	115	787	2	20,000	50[b]	85[b]	74[b]
Hardness (mg $CaCO_3$/L)	36	68.4	34	130	N/A	N/A	N/A
Nitrate-nitrite nitrogen (mg/L)	115	0.542	0.022	1.8	N/A	N/A	N/A
Total phosphorus (mg/l)	115	0.035	0.005	0.27	N/A	N/A	N/A
Total copper (μg/L)	115	3.72	0.778	81	11.9[c]	5[c]	4[c]
Total lead (μg/L)	114	1.52	0.15	11	42.6[c]	0[c]	0[c]
Total zinc (μg/L)	90	15.7	0.545	73	82.9[c]	0[c]	0[c]
Total suspended solids (mg/L)	93	6.8	1	35	N/A	N/A	N/A

Source Snohomish County (2002b)
N/A = Not Applicable, no surface water quality standard exists (Chapter 173-201A WAC).

[a] The turbidity standard is based on comparison of values for locations upstream (background) and downstream of turbidity sources. The application of the standard to only one location on a stream is not appropriate (N/A).
[b] The fecal coliform bacteria standard is based on a geometric mean value (Chapter 173-201A WAC), but individual sample values were compared to this standard for determining the number and percent of non-standard values.
[c] Metals standards include acute and chronic standards that are based on dissolved metals and depend on hardness. Metals standards shown are acute standards for dissolved metals at the mean hardness value. Total metals were converted to dissolved metals using conversion factors in Chapter 173-201A WAC and compared to the acute standard using the hardness value measured during sampling, or using the mean hardness value for this station if the sample hardness was not available.

Total copper, lead, and zinc were measured during baseline sampling events. Total lead concentrations were low, with a mean concentration of 1.52 μg/L. Lead and zinc did not exceed their respective acute toxicity standards (Ecology 1997a). However, total copper concentrations, after conversion to the dissolved fraction, exceeded the acute standard five times during sampling. Snohomish County has found concentrations of copper, lead, and zinc in North Creek to be the highest among the County's baseline sampling stations (King County 2002a).

Sampling indicates the Snohomish County's McCollum Park station (NCLU) has lower mean dissolved oxygen concentrations, slightly cooler water temperatures, and higher fecal coliform bacteria concentrations than the King County station located at the mouth of the stream (Site 0474).

Stream Discharge

Snohomish County measures North Creek discharge at the Snohomish-King County line. Based on water years 1995 through 2001, average wet season (October through May) flows were 82.3 cfs and average dry season (June through September) flows were 21.6 cfs (Snohomish County 2002b). These averages were calculated from daily average hourly measurements. Historic flows were measured by the U.S. Geological Survey (USGS) in North Creek at Bothell from 1946 through 1973 (USGS 1985). The maximum discharge of 680 cfs was recorded by the USGS on May 5, 1949 (USGS 1985).

Sediment Data

Sediment data were collected by King County at the mouth of North Creek annually from 1995 through 2000 and analyzed for selected metals (Table 16). During sampling, silver and mercury were not detected and arsenic, cadmium, copper, lead, nickel, and zinc were detected at least once. Sampling indicates sediment quality is good with metals concentrations that do not exceed applicable sediment thresholds (Ecology 1997b).

Table 16. Sediment data collected by King County near the mouth of North Creek from 1995 through 2000 (Site 0474).

Stream Sediment Metal Concentrations (mg/kg dry weight)			
	Sediment Threshold (Ecology 1997b)	Mean	Minimum – Maximum
Arsenic	None	<5.5	<Detection – 9.2
Silver	None	<0.004[a]	<0.004[a]
Mercury	2	<0.0002[a]	<0.0002[a]
Cadmium	10	<0.23	<0.002[a] – 0.39
Copper	110	7.0	5.7 – 8.7
Lead	250	3.1	3.1
Nickel	75	12.4	20.4
Zinc	820	31.6	24.7 – 43.3

Source: King County (2002b)
[a] Detection limit

Swamp Creek Basin

Swamp Creek originates in the City of Everett at the outlet of Lake Stickney located south of Paine Field. The stream flows south through the Cities of Lynnwood, Brier, Bothell, Mountlake

Terrace, and Kenmore and flows into the Sammamish River near Lake Washington at RM 0.6. Swamp Creek is designated a Class AA (extraordinary) surface water by Ecology (Ecology 1997a). The mainstem of the stream is 10.9 miles in length. The lower 1.5 miles above the City of Kenmore have been channelized to control flooding (WDFW 1975). The drainage basin covers approximately 15,000 acres, with 52 percent of the watershed consisting of impervious surface from urban land uses (King County 2002b).

The main tributary of Swamp Creek is Scriber Creek, which originates as the outflow of Scriber Lake. Several tributaries enter Scriber Creek upstream of its confluence with Swamp Creek at RM 4.5. The basin includes Martha Lake, Lake Stickney, and Scriber Lake. Martha Creek is an intermittent stream that drains Martha Lake.

On Ecology's 1996 and 1998 303(d) lists, Swamp Creek (Segment Id No. WA-08-1060, mouth to RM 10.9) is listed as impaired for fecal coliform bacteria and dissolved oxygen (Ecology, 1996; and 1998). Martha Lake (Segment Id No. WA-08-9190) and Scriber Lake (Segment Id No. WA-08-9280) are identified as impaired for total phosphorus on the 1996 and 1998 303(d) lists (Ecology, 1996; 1998). However, no TMDL study or basin action plan has been initiated by Ecology to address these Swamp Creek basin water quality impairments.

In Ecology's 1994 305(b) assessment (Ecology 1995), Swamp Creek (Segment Id. No.: 08-1060) is identified as supporting the following uses: rearing, harvesting and other fish spawning, salmonid spawning, and salmonid other fish migration. This segment is impaired for primary and secondary contact recreation with impairment sources cited as land development and urban runoff/storm sewers. The assessment identified the causes of impairment as fecal coliform bacteria and/or other pathogen indicators.

Water Quality

King County and Snohomish County have long-term water quality sampling stations in the mainstem of Swamp Creek. The station locations and duration of water quality monitoring are listed in Table 17. The following water quality characterization summarizes the long-term monitoring results.

Table 17. Summary of long-term Swamp Creek surface water quality monitoring stations and duration of sampling.

Sampling Location	Water Quality Sampling Record	Agency	Frequency of Sampling
Near Bothell Way and 80th Avenue NE (Site 0470)	1979-1999[a]	King County	Monthly
Near Bothell Way and 80th Avenue NE (Site 0470)	1987-2000[a]	King County	Storm[b]
148th Street SW (Upstream Station SCLU)	1992-2002	Snohomish County	Monthly
24225 Lockwood Road (Downstream Station SCLD)	1992-2002	Snohomish County	Monthly

Source: King County (2002a,b) and Snohomish County (2002b).

[a] King County continues to collect water quality data at this station; however; results are only available for the water quality sampling record shown.

[b] King County collects storm flow samples at this station three to six times annually. Trace metals samples reported were collected from 1995 through 2000.

King County collects ambient water quality samples monthly at the mouth of Swamp Creek near Bothell Way and 80th Avenue NE (Site 0470) (Table 18). Based on data collected from 1979 through 1999, the waters of Swamp Creek are generally cool and neutral, with high fecal coliform bacteria concentrations. The stream's water quality can be characterized as good (Metro, 1986; 1987; 1988; 1989; and 1990). Sampling indicates dissolved oxygen concentrations do not meet the minimum Class AA criterion of 9.5 mg/L 31 percent of time; however, the mean concentration (10.27 mg/L) exceeds this minimum standard. Sporadic measurements of temperature, turbidity, and pH also do not meet applicable Class AA criteria. Sampling indicates fecal coliform bacteria do not meet the Class AA criterion 68 percent of the time. Fecal coliform bacteria are present in the stream at relatively high concentrations, with a mean of 180 CFU/100 mL.

The nutrient concentrations found in Swamp Creek are similar to most of the streams sampled by King County (King County 2002a). The Swamp Creek total phosphorus concentration is slightly elevated, with a mean of 0.064 mg/L measured by King County over a 20-year period. Sampling indicates that nitrate nitrogen concentration is high, with a mean of 1.00 mg/L also measured over the 20-year sampling period. Sources of nitrate nitrogen include fertilizer use and livestock waste (King County 2002a).

Table 18. Swamp Creek summary of ambient water quality data collected by King County and Metro from 1979 through 1999 near Bothell Way and 80th Avenue North (Site 0470).

Parameter	Number of Samples	Mean	Minimum	Maximum	Class AA Standards	Number Non-Standard	Percent Non-Standard
Flow (cfs)	196	33.0	2.2	466	N/A	N/A	N/A
Dissolved oxygen (mg/L)	231	10.3	6.5	15	9.5	71	31.40
Temperature (°C)	249	10.1	0.1	19	16.0	16	6.43
Turbidity (NTU)	236	3.97	0.2	52	N/A[a]	N/A[a]	N/A[a]
pH (standard units)	231	7.31	6.1	8.1	6.5 – 8.5	2	0.87
Conductivity (μmhos/cm)	234	163	85	231	N/A	N/A	N/A
Total suspended solids (mg/L)	236	7.28	0.5	136	N/A	N/A	N/A
Ortho-phosphorus (mg/L)	232	0.034	0.003	0.186	N/A	N/A	N/A
Total Phosphorus (mg/L)	235	0.064	0.007	0.347	N/A	N/A	N/A
Ammonia nitrogen (mg/L)	202	0.025	0.001	0.161	N/A[b]	N/A[b]	N/A[b]
Nitrate nitrogen (mg/L)	232	0.997	0.014	2.32	N/A	N/A	N/A
Total nitrogen (mg/L)	77	1.30	0.73	2.9	N/A	N/A	N/A
Enterococcus (CFU/100 mL)	129	92	8	16,000	N/A	N/A	N/A
Fecal coliform bacteria (CFU/100 mL)	237	180	0	24,000	50[c]	161[c]	67.9[c]

Source: King County (2002b)
N/A = Not Applicable, no surface water quality standard exists (Chapter 173-201A WAC).

a The turbidity standard is based on comparison of values for locations upstream (background) and downstream of turbidity sources. The application of the standard to only one location on a stream is not appropriate (N/A).

[b] The ammonia standard includes acute and chronic criteria that vary depending on pH, temperature, and the presence of salmonids. Assuming salmonids are present at typical worst-case conditions of high temperature (16°C) and high pH (8.0), acute and chronic criteria are 5.6 and 1.0 mg/L as nitrogen, respectively. The ammonia standard was not applied to the sample values.

[c] The fecal coliform bacteria standard is based on a geometric mean value (Chapter 173-201A WAC), but individual sample values were compared to this standard for determining the number and percent of non-standard values.

Based on the long-term monitoring at this station by King County, the total phosphorus, ortho-phosphorus, fecal coliform bacteria, and dissolved oxygen concentrations have decreased, whereas temperature and conductivity have increased over time (King County 2002a). However, the dissolved oxygen concentration has been increasing since 1993 (King County 2002a). The

pH has also decreased at this sampling station with the cause of the decline attributed to urbanization and an increase in stormwater runoff (King County 2002a). Similar to North Creek as described above, the decline in phosphorus concentrations may be due to the implementation of best management practices in the watershed (King County 2002a). Temperature increases could be attributed to climatic changes or removal of riparian vegetation or some other long-term trend; however, the specific cause has not been determined (King County 2002a).

King County collects storm flow samples in Swamp Creek at the same location as ambient sampling, near the stream's mouth at the Sammamish River (Site 0470) (Table 19). Based on storm samples collected from 1987 through 2000, the waters of Swamp Creek are generally cool, with a neutral pH, but degraded because of moderately high turbidity, total suspended solids, and fecal coliform bacteria concentrations. Sampling indicates that turbidity, dissolved oxygen, and fecal coliforms do not meet Class AA criteria during storms. Sporadic measurements of pH and temperature also do not meet Class AA criteria during storms. Based on these results, the water quality of Swamp Creek during storm flows is characterized as fair to good.

Sampling indicates that fecal coliform bacteria do not meet the Class AA criterion 96 percent of the time. The mean turbidity during storm sampling is moderately high, at 8.5 NTU. Dissolved oxygen does not consistently meet the Class AA minimum criterion of 9.5 mg/L; however, the mean concentration of 10.0 mg/L meets this criterion. The total phosphorus concentration is moderately high, with a mean total phosphorus concentration of 0.103 mg/L. Metals data were also collected by King County at this station from 1995 through 2000 during storm events. During storm sampling, metals concentrations were low, meeting applicable metals criteria (Ecology 1997a) (King County 2002b).

Table 19. Swamp Creek summary of storm water quality data collected by King County and Metro from 1987 through 2000 near Bothell Way and 80th Avenue North (Site 0470).

Parameter	Number of Samples	Mean	Minimum	Maximum	Class AA Standards	Number Non-Standard	Percent Non-Standard
Flow (cfs)	21	62	22	160	N/A	N/A	N/A
Dissolved oxygen (mg/L)	26	10	7	13	9.5	10	39
Temperature (°C)	27	9.4	2.5	16.3	16.0	1	3.7
Turbidity (NTU)	27	8.5	1.6	24.0	N/A[a]	N/A[a]	N/A[a]
pH (standard units)	27	7.0	6.4	7.9	6.5 – 8.5	2	7.4
Conductivity (μmhos/cm)	27	136	79.1	191	N/A	N/A	N/A
Total suspended solids (mg/L)	27	21.4	4.0	72.0	N/A	N/A	N/A
Ortho-phosphorus (mg/L)	27	0.034	0.009	0.141	N/A	N/A	N/A
Total Phosphorus (mg/L)	27	0.103	0.038	0.222	N/A	N/A	N/A
Ammonia nitrogen (mg/L)	19	0.047	0.014	0.200	N/A[b]	N/A[b]	N/A[b]

Parameter	Number of Samples	Mean	Minimum	Maximum	Class AA Standards	Number Non-Standard	Percent Non-Standard
Nitrate nitrogen (mg/L)	27	0.783	0.306	2.00	N/A	N/A	N/A
Total nitrogen (mg/L)	23	1.30	0.791	2.30	N/A	N/A	N/A
Enterococcus (CFU/100 mL)	27	858	99	7,200	N/A	N/A	N/A
Fecal coliform bacteria (CFU/100 mL)	27	694	57	4,600	50[c]	26[c]	96.3[c]

Source: King County (2002a)
N/A = Not Applicable, no surface water quality standard exists (Chapter 173-201A WAC).

[a] The turbidity standard is based on comparison of values for locations upstream (background) and downstream of turbidity sources. The application of the standard to only one location on a stream is not appropriate (N/A).
[b] The ammonia standard includes acute and chronic criteria that vary depending on pH, temperature, and the presence of salmonids. Assuming salmonids are present at typical worst-case conditions of high temperature (16°C) and high pH (8.0), acute and chronic criteria are 5.6 and 1.0 mg/L as nitrogen, respectively. The ammonia standard was not applied to the sample values.
[c] The fecal coliform bacteria standard is based on a geometric mean value (Chapter 173-201A WAC), but individual sample values were compared to this standard for determining the number and percent of non-standard values.

When comparing King County storm versus ambient results for Swamp Creek, the mean turbidity, total suspended solids, total phosphorus, ammonia, and fecal coliform bacteria concentrations were higher during storms than those measured during monthly sampling. The mean storm flow dissolved oxygen concentration was essentially equal to the mean measured during ambient sampling. The mean storm flow temperature was slightly cooler (9.4°C) than the mean measured during ambient sampling (10.14°C). The nitrate nitrogen concentration is slightly higher during ambient sampling (mean of 0.997 mg/L) than that measured during storms (mean of 0.783 mg/L), suggesting a baseflow component, that is diluted during storm events (King County 2002b). Total phosphorus concentrations are higher during storms than those measured during ambient conditions. Phosphorus readily binds to particulate matter, and because during storms the amount of suspended material present is much higher than during ambient sampling, the total phosphorus concentration is also higher (King County 2002b).

Snohomish County has collected water quality samples monthly at two locations in Swamp Creek as part of their ambient monitoring program (Tables 20 and 21). An upper station located at 148th Street and a lower station located at Lockwood Road, have been monitored since 1992. Similar to the data collected by King County (Site 0470) at the mouth of Swamp Creek, water quality is generally good, but degraded because of high fecal coliform concentrations.

Table 20. Swamp Creek summary of ambient water quality data collected by Snohomish County from 1992 through 2002 at 148th Street SW (Upper Station: Site SCLU).

Minimum	Number of Samples	Mean	Minimum	Maximum	Class AA Standards	Class AA Violations	Percent Not Meeting Standards
Staff depth (feet)	94	3.07	0.01	4.05	N/A	N/A	N/A
Temperature (°C)	104	9.39	1.6	18	16.0	5	5
Dissolved oxygen (mg/L)	104	9.15	2.46	13.9	9.5	53	51
pH (standard units)	103	7.01	5.83	8.4	6.5-8.5	10	10
Conductivity (μmhos/cm)	100	116	17.4	606	N/A	N/A	N/A
Turbidity (NTU)	39	2.66	0.54	19.9	N/A[a]	N/A[a]	N/A[a]
Fecal coliform bacteria (CFU/100mL)	103	1,230	1	48,000	50[b]	68[b]	66[b]
Hardness (mg $CaCO_3$/L)	29	48.5	31	110	N/A	N/A	N/A
Nitrate- nitrite nitrogen (mg/L)	104	0.605	0.012	3.2	N/A	N/A	N/A
Total phosphorus (mg/L)	103	0.032	0.005	0.237	N/A	N/A	N/A
Total copper (ug/L)	96	3.21	0.07	73	8.61[c]	4	4
Total lead (ug/L)	91	1.43	0.01	12	29.1[c]	None	0
Total zinc (ug/L)	72	11.9	1.89	120	62.0[c]	3	4
Total suspended solids (mg/L)	72	5.96	1	65	N/A	N/A	N/A

Source: Snohomish County (2002b)
NA = Not Applicable, no surface water quality standard exists (Chapter 173-201AWAC).

[a] The turbidity standard is based on comparison of values for locations upstream (background) and downstream of turbidity sources. The application of the standard to only one location on a stream is not appropriate (N/A).

[b] The fecal coliform bacteria standard is based on a geometric mean value (Chapter 173-201AWAC), but individual sample values were compared to this standard for determining the number and percent of non-standard values.

[c] Metals standards include acute and chronic standards that are based on dissolved metals and depend on hardness. Metals standards shown are acute standards for dissolved metals at the mean hardness value. Total metals were converted to dissolved metals using conversion factors in Chapter 173-201A WAC and compared to the acute standard using the hardness value measured during sampling, or using the mean hardness value for this station if the sample hardness was not available.

Table 21. Swamp Creek summary of ambient water quality data collected by Snohomish County from 1992 through 2002 at Lockwood Road (Lower Station: Site SCLD).

Parameter	Number of Samples	Mean	Minimum	Maximum	Class AA Standards	Class AA Violations	Percent Not Meeting Standard
Staff depth (feet)	101	0.71	0.04	3.5	N/A	N/A	N/A
Temperature (°C)	115	10.6	2.3	19.1	16.0	7	6
Dissolved oxygen (mg/L)	114	10.9	5.34	14.8	9.5	10	9
pH (standard units)	114	7.57	6.38	8.88	6.5-8.5	3	3
Conductivity (μmhos/cm)	110	147	37.1	231	N/A	N/A	N/A
Turbidity (NTU)	48	3.43	0.7	23.6	N/A[a]	N/A[a]	N/A[a]
Fecal coliform bacteria (CFU/100mL)	115	595	4	7,300	50[b]	91[b]	79[b]
Hardness (mg CaCO3/L)	36	75.1	41	320	N/A	N/A	N/A
Nitrate - nitrite nitrogen (mg/L)	114	0.97	0.05	2.5	N/A	N/A	N/A
Total phosphorus (mg/L)	115	0.052	0.019	0.12	N/A	N/A	N/A
Total copper (ug/L)	115	2.96	0.07	73	13.0[c]	4	3
Total lead (ug/L)	114	1.47	0.032	17	47.2[c]	None	0
Total zinc (ug/L)	91	8.47	0.44	100	89.8[c]	1	1
Total suspended solids (mg/L)	91	17.2	1	540	N/A	N/A	N/A

Source: Snohomish County (2002b)
NA = Not Applicable, no surface water quality standard exists (Chapter 173-201AWAC).

[a] The turbidity standard is based on comparison of values for locations upstream (background) and downstream of turbidity sources. The application of the standard to only one location on a stream is not appropriate (N/A).
[b] The fecal coliform bacteria standard is based on a geometric mean value (Chapter 173-201AWAC), but individual sample values were compared to this standard for determining the number and percent of non-standard values.
[c] Metals standards include acute and chronic standards that are based on dissolved metals and depend on hardness. Metals standards shown are acute standards for dissolved metals at the mean hardness value. Total metals were converted to dissolved metals using conversion factors in Chapter 173-201A WAC and compared to the acute standard using the hardness value measured during sampling, or using the mean hardness value for this station if the sample hardness was not available.

The waters of Swamp Creek are cool and neutral with high fecal coliform bacteria concentrations and, in the upper basin, low dissolved oxygen concentrations. At the upper station (148th Street), dissolved oxygen does not meet the minimum Class AA criterion of 9.5 mg/l 51 percent of the time compared to the lower station, where concentrations fail to meet the minimum criterion 9 percent of the time. Low dissolved oxygen concentrations are generally recorded during the summer and early fall (June through October) when water temperatures are the warmest. Sampling indicates that fecal coliform bacteria do not meet the Class AA criterion 66 percent of the time at the upper station (148th Street) and 79 percent at the lower station (Lockwood Road). Fecal coliform bacteria are present in the creek at high

concentrations with means of 1,225 CFU/100 mL at 148th Street (upper) station and 595 CFU/100 mL at the Lockwood Road (lower) station.

Total copper, lead, and zinc were measured during ambient sampling events. Overall, total metals concentrations were generally low. The mean total zinc concentration was slightly higher at the upper station (11.86 μg/L) than the mean measured at the lower station (8.47 μg/L). Total metals concentrations were converted to the dissolved fraction using conversion factors in Chapter 201-173 WAC prior to comparison to standards. At both stations, total lead did not exceed the respective acute toxicity standard (Ecology 1997a). Total copper exceeded the acute standard four times each at the lower station (Lockwood Road) and the upper station (148th Street SW). Total zinc exceeded the acute standard once at the lower station (Lockwood Road) and three times at the upper station (148th Street SW). However, the metals standards apply to the dissolved fraction of the metal and not the total, so it is not possible to confirm direct violation of the standard with the total metals data reported.

In comparing Snohomish County's upstream station (148th Street SW) results with the downstream results (Lockwood Road), the downstream station has higher mean concentrations of nitrate-nitrite nitrogen, total phosphorus, and total suspended solids as well as higher pH, temperature, conductivity and turbidity. The upper station has a higher mean fecal coliform bacteria concentration and a lower mean dissolved oxygen concentration.

Stream Discharge

Snohomish County measures stream discharge at Interstate 405. Based on water years 1995 through 2001, average wet season (October through May) flows were 22.4 cfs and average dry season (June through September) flows were 3.0 cfs (Snohomish County 2002b). These averages were calculated from daily average hourly measurements. King County measures stream discharge during monthly water quality sampling events. Based on results from 1979 through 1999, average discharge was 32.96 cfs, with the highest recorded discharge of 466 cfs and the lowest discharge of 2.2 cfs (King County 2002b).

Sediment Quality

Sediment data were collected by King County at the mouth of Swamp Creek annually from 1995 through 2000 and were analyzed for selected metals (Table 22). During sampling, arsenic, silver, mercury and cadmium were not detected and copper, lead, nickel, and zinc were detected at least once. Sampling indicates that sediment metals concentrations met applicable sediment thresholds (Ecology 1997b).

Table 22. Sediment data collected by King County near the mouth of Swamp Creek from 1995 through 2000 (Site 0470).

Stream Sediment Metal Concentrations (mg/kg dry weight)			
	Sediment Threshold (Ecology 1997b)	Mean	Minimum – Maximum
Arsenic	None	<0.05[a]	<0.05[a]
Silver	None	<0.004[a]	<0.004[a]
Mercury	2	<0.0002[a]	<0.0002[a]
Cadmium	10	<0.002[a]	<0.002[a]
Copper	110	5.4	3.6 – 6.8
Lead	250	4.3	3.1 – 6.1
Nickel	75	18.1	8.5 – 26.8
Zinc	820	34	22.9 – 56.2

Source: King County (2002b)
[a] Detection limit

Pesticides

As part of the Sammamish/Washington Analysis and Modeling Program (SWAMP), King County conducted a Small Streams Toxicity Study to investigate the possible biological effects associated with the presence of pesticides in small urban streams in King County (King County 2002d). Swamp Creek was one of the three urban streams included in the 2000 study. Streams were tested for toxicity, pesticides, and metals during four sampling events (two spring storms, a summer baseline event, and one fall storm). During the 2000 study, some of the pesticides most frequently detected during storm events included the insecticide diazinon, the herbicides 2,4-D, dichlobenil, MCPP, prometon, trichlopyr, and the insecticide/fungicide pentachlorophenol (King County 2002c). In general, the study detected fewer pesticides during the June baseline sampling than during storm flow events (King County 2002c). Sampling results indicate that 12 pesticides were detected in Swamp Creek during the 2000 events (King County 2002c). Five metals were detected during sampling; however, all were measured at concentrations not considered harmful to aquatic communities (King County 2002c).

Toxicity was observed during the baseflow event and the fall storm flow event for green algae (*Selenastrum capricornutum*) in the unfiltered sample. However, filtering of the samples removed the observed toxicity, suggesting the toxicant(s) were associated with particulates in the sample (King County 2002c). Toxicity was observed for vascular aquatic plants (*Lemna minor*) in the early and late May storm and June 2000 baseflow samples. Only unfiltered samples were analyzed for *Lemna minor*. Toxicity was observed for the water flea (*Ceriodaphnia dubia*) in the June baseline filtered sample. This result, however, may not be chemically related.

Lyon Creek Basin

Lyon Creek originates in a wetland area in south Snohomish County and flows south through the Cities of Mountlake Terrace, Brier and Lake Forest Park before flowing directly into the north

end of Lake Washington. The stream is designated a Class AA (extraordinary) surface water by Ecology (Ecology 1997a). The mainstem of the stream is 3.8 miles in length and the drainage basin is approximately 2,600 acres in size. The Lyon Creek Headwaters are located in Mountlake Terrace at an elevation of 390 feet, and the stream drops steeply through most of its course before leveling out to a broad plain near its mouth at Lake Forest Park on Lake Washington. The basin is highly urbanized with land use consisting of 66 percent residential, 4.7 percent commercial, and 0.3 percent industrial (King County 2002d). The remaining 29 percent consists of open space, parks, and forested cover (King County 2002a).

On Ecology's 1996 and 1998 303(d) water quality limited lists, Lyon Creek (Segment Id No. WA-08-1040, mouth to RM 3.6) is listed for fecal coliform bacteria (Ecology 1996; Ecology 1998). In the 1994 305(b) assessment (Ecology 1995), Lyon Creek (Segment Id. No.: 08-1040) is identified as supporting the following uses: rearing, harvesting and other fish spawning, salmonid spawning, and salmonid other fish migration. This segment is considered to be impaired for primary and secondary contact recreation with impairment sources cited as urban runoff and/or storm sewers. The assessment identified the causes of impairment as fecal coliform bacteria and/or other pathogen indicators.

Water Quality

King County collects water quality samples monthly in the mainstem of Lyon Creek (Site 0430) near its mouth at the Lake Forest Park Civic Club Bridge at the shore of Lake Washington (Table 23). Based on data collected from 1979 through 1999, the waters of Lyon Creek are generally cool, slightly turbid, and well oxygenated with high total suspended solids, nitrate nitrogen, and fecal coliform bacteria concentrations. Sporadic measurements of dissolved oxygen, temperature, and pH did not meet specific Class AA criteria. The stream's water quality can be characterized as poor to good (Metro, 1986; 1987; 1988; 1989; 1990; and 1994). Sampling indicates that fecal coliform bacteria do not meet the Class AA criterion 88 percent of the time. Fecal coliform bacteria are present in high concentrations with a mean of 383 CFU/100 mL.

Lyon Creek total phosphorus concentrations are slightly elevated, with a mean concentration of 0.063 mg/L measured by King County. The mean nitrate nitrogen concentration is high, 1.22 mg/L. Sources of nitrate nitrogen include commercial and residential fertilizer use (King County 2002a).

Based on the long-term monitoring at this station, temperature and conductivity have been increasing at this site over the last 20 years (King County 2002a). Increases in temperature can be attributed to climatic changes, removal of riparian vegetation, or some other long-term trend; however, the specific cause has not determined (King County 2002a). The basin has undergone an increase in urbanization over the last 20 years, which could have contributed to the relatively high total suspended solids concentrations measured at this station (King County 2002a). Unlike the other long-term stream sites monitored by King County, fecal coliform bacteria and enterococcus bacteria concentrations do not seem to be declining in Lyon Creek and are likely due to the high amount of urbanization within the basin (King County 2002a).

Table 23. Summary of Lyon Creek ambient water quality data collected by King County and Metro from 1979 through 1999 (Site 0430).

Parameter	Number of Samples	Mean	Minimum	Maximum	Class AA Standards	Number Non-Standard	Percent Non-Standard
Flow (cfs)	222	5.32	0.29	33	N/A	N/A	N/A
Dissolved oxygen (mg/L)	236	11.0	8	13.6	9.5	8	3.5
Temperature (°C)	234	10.1	0.6	18	16.0	7	2.99
Turbidity (NTU)[b]	237	4.85	0.2	125	N/A[a]	N/A[a]	N/A[a]
pH (standard units)	235	7.49	6.46	8.1	6.5 – 8.5	1	0.43
Conductivity (μmhos/cm)	236	197	72	351	N/A	N/A	N/A
Total suspended solids (mg/L)	237	11.4	0.01	362	N/A	N/A	N/A
Ortho-phosphorus (mg/L)	235	0.032	0.002	0.203	N/A	N/A	N/A
Total Phosphorus (mg/L)	237	0.063	0.007	0.466	N/A	N/A	N/A
Ammonia nitrogen (mg/L)	193	0.031	0.001	1.022	N/A[b]	N/A[b]	N/A[b]
Nitrate nitrogen (mg/L)	233	1.22	0.477	2.8	N/A	N/A	N/A
Total nitrogen (mg/L)	77	1.50	0.971	2.5	N/A	N/A	N/A
Enterococcus (CFU/100 mL)	148	281	19	17,000	N/A	N/A	N/A
Fecal coliform bacteria (CFU/100 mL)	238	383	20	13,200	50[c]	210[c]	88.2[c]

Source: King County (2002b)

NA = Not Applicable, no surface water quality standard exists (Chapter 173-201A WAC).

[a] The turbidity standard is based on comparison of values for locations upstream (background) and downstream of turbidity sources. The application of the standard to only one location on a stream is not appropriate (N/A).

[b] The ammonia standard includes acute and chronic criteria that vary depending on pH, temperature, and the presence of salmonids. Assuming salmonids are present at typical worst-case conditions of high temperature (16°C) and high pH (8.0), acute and chronic criteria are 5.6 and 1.0 mg/L as nitrogen, respectively. The ammonia standard was not applied to the sample values.

[c] The fecal coliform bacteria standard is based on a geometric mean value (Chapter 173-201A WAC), but individual sample values were compared to this standard for determining the number and percent of non-standard values.

King County collects storm flow samples in Lyon Creek at the same location as ambient sampling, near the stream's mouth at the shore of Lake Washington (Site 0430) (Table 24). Based on storm samples collected from 1987 through 2000, the waters of Lyon Creek are generally cool, well oxygenated, with a neutral pH, but degraded because of high turbidity, total suspended solids, and fecal coliform bacteria concentrations. Sampling indicates that fecal coliform bacteria concentrations do not meet Class AA criteria during storms. Two temperature measurements did not meet applicable the Class AA criterion of 16.0°C. Based on these results,

the storm flow water quality of Lyon Creek is characterized as fair to good. The mean turbidity during storm events was 15.0 NTU. Total phosphorus concentrations are also high during storm events, with a mean concentration of 0.153 mg/L. Metals data were also collected by King County at this station from 1995 through 2000 during storm events. During storm sampling, Lyon Creek exceeded the criteria for lead once, zinc and nickel twice, and copper seven times (King County 2002b).

Table 24. Summary of Lyon Creek storm water quality data collected by King County and Metro from 1987 through 2000 (Site 0430).

Parameter	Number of Samples	Mean	Minimum	Maximum	Class AA Standards	Number Non-Standard	Percent Non-Standard
Flow (cfs)	1	39	39	39	N/A	N/A	N/A
Dissolved oxygen (mg/L)	29	11	9	13	9.5	3	10
Temperature (°C)	29	10.1	3.0	16.8	16.0	2.0	6.9
Turbidity (NTU)[b]	30	15.0	3.2	40	N/A[a]	N/A[a]	N/A[a]
pH (standard units)	30	7.2	6.8	8.0	6.5 – 8.5	0	0
Conductivity (μmhos/cm)	30	107	61	180	N/A	N/A	N/A
Total suspended solids (mg/L)	30	46.2	5.5	200	N/A	N/A	N/A
Ortho-phosphorus (mg/L)	30	0.028	0.011	0.075	N/A	N/A	N/A
Total Phosphorus (mg/L)	30	0.153	0.044	0.520	N/A	N/A	N/A
Ammonia nitrogen (mg/L)	23	0.041	0.019	0.082	N/A[b]	N/A[b]	N/A[b]
Nitrate nitrogen (mg/L)	30	0.746	0.410	1.73	N/A	N/A	N/A
Total nitrogen (mg/L)	25	1.32	0.872	2.27	N/A	N/A	N/A
Enterococcus (CFU/100 mL)	30	2,810	500	20,000	N/A	N/A	N/A
Fecal coliform bacteria (CFU/100 mL)	30	1,780	320	6,700	50[c]	30[c]	100[c]

Source: King County (2002a)
NA = Not Applicable, no surface water quality standard exists (Chapter 173-201A WAC).

[a] The turbidity standard is based on comparison of values for locations upstream (background) and downstream of turbidity sources. The application of the standard to only one location on a stream is not appropriate (N/A).
[b] The ammonia standard includes acute and chronic criteria that vary depending on pH, temperature, and the presence of salmonids. Assuming salmonids are present at typical worst-case conditions of high temperature (16°C) and high pH (8.0), acute and chronic criteria are 5.6 and 1.0 mg/L as nitrogen, respectively. The ammonia standard was not applied to the sample values.
[c] The fecal coliform bacteria standard is based on a geometric mean value (Chapter 173-201A WAC), but individual sample values were compared to this standard for determining the number and percent of non-standard values.

When comparing King County storm versus ambient results for Lyon Creek, mean turbidity, total suspended solids, total phosphorus, total nitrogen, ammonia and fecal coliform bacteria

concentrations are higher during storms than those measured during ambient sampling. The mean storm temperature and dissolved oxygen concentrations are essentially equal to the means measured during baseline sampling. The mean nitrate nitrogen concentration (0.746 mg/L) is lower during storms than during ambient sampling (1.22 mg/L), suggesting a baseflow component that is diluted during storms (King County 2002a). Total phosphorus concentrations are more than double during storms than those measured during ambient sampling. Phosphorus readily binds to particulate matter and, because during storms the amount of suspended material present is much higher than during ambient conditions, the total phosphorus concentration is also higher (King County 2002b).

Stream Discharge

King County collected stream discharge measurements in Lyon Creek at the Lake Forest Park Civic Club Bridge for the 1992 through 1994 water years and the 2001 water year (King County 2002e). The average wet season (October through May) stream discharge was 4.4 cfs (compiled from daily average flow data); and the average dry season (June through September) stream discharge was 2.0 cfs (compiled from daily average flow data).

Sediment Quality

Sediment data were collected by King County at the mouth of Lyon Creek annually from 1995 through 2000 and analyzed for selected metals (Table 25). During sampling, arsenic, silver, and cadmium were not detected; mercury, copper, lead, nickel, and zinc were detected at least once. Sampling indicates that sediment metals concentrations meet applicable sediment thresholds (King County 1997b).

Table 25. Sediment data collected by King County near the mouth of Lyon Creek from 1995 through 2000 (Site 0430).

Stream Sediment Metal Concentrations (mg/kg dry weight)			
	Sediment Threshold(Ecology 1997b)	Mean	Minimum – Maximum
Arsenic	None	<0.05[a]	<0.05[a]
Silver	None	<0.004[a]	<0.004[a]
Mercury	2	<0.022	<0.0002a – 0.028
Cadmium	10	<0.002[a]	<0.002[a]
Copper	110	7.3	6.5 – 7.9
Lead	250	10.8	11.1 – 12.8
Nickel	75	17.2	7.5 – 20.5
Zinc	820	47.0	35.8 – 60.9

Source: King County (2002b)
[a] Detection limit

Pesticides Study

As part of the Sammamish/Washington Analysis and Modeling Program (SWAMP), King County and the USGS conducted a Small Streams Toxicity Study to investigate the possible biological effects associated with the presence of pesticides in selected small urban streams in King County (King County 2002f). Lyon Creek was one of the three urban streams sampled in the study in 1998, 1999, and 2000. Streams were tested for toxicity, pesticides and metals during four sampling events (a spring storm, a summer baseflow event, an early fall storm, and a late fall storm). Results combined for all urban sites during the 1999 study show that the greatest numbers of pesticides were detected in spring and summer samples, and pesticide concentrations were highest in spring and fall samples (King County 2002f). During the study, the most frequently detected pesticides included 2,4-D, diclobenil, trichlopyr, diazinon, and pentachlorophenal (King County 2002f).

During the King County study, 21 pesticides were detected in Lyon Creek waters (King County 2002d). Lyon Creek exceeded the chronic standard for copper once (spring), and the acute and chronic standard for aluminum once (late fall sampling). Toxicity was observed in the initial sampling during May 1998 for the three species tested, water flea (*Ceriodaphnia dubia*), vascular plants (*Lemna minor*), and green algae (*Selenastrum capricornutum*). In spring 1999, toxicity to green algae was observed. However, in both May 1998 and spring 1999 for *Selenastrum*, filtering of the samples removed the observed toxicity, suggesting the toxicant(s) were associated with particulates in the sample (King County 2002d). However, no toxicity was observed in samples collected during summer baseflows in 1999.

Two tributaries to the Sammamish River were also included in the 2000 study, Little Bear Creek and Swamp Creek. Streams were tested for toxicity, pesticides, and metals during four sampling events (two spring storms, a summer baseflow event, and one fall storm). During the 2000 study, some of the pesticides most frequently detected during storm events included the insecticide diazinon, the herbicides 2,4-D, dichlobenil, MCPP, prometon, and trichlopyr, and the insecticide/fungicide pentachlorophenol (King County 2002c). Sampling results indicate that 18 pesticides and 10 metals were detected. Diazinon was detected in spring stormwater levels expected to cause adverse effects to aquatic life. No metals were measured at concentrations harmful to aquatic communities (King County 2002c).

Toxicity was observed in the early May storm and ambient samples for green algae (*Selenastrum capricornutum*) in the unfiltered sample. However, filtering of the samples removed the observed toxicity, suggesting the toxicant(s) were associated with particulates in the sample (King County 2002c). Toxicity was observed for aquatic vascular plants (*Lemna minor*) in the early and late May storm and June 2000 baseline samples. Only unfiltered samples were analyzed for *Lemna minor*. Toxicity was not observed for the water flea (*Ceriodaphnia dubia*) in the filtered or unfiltered sample.

McAleer Creek Basin

McAleer Creek originates at Lake Ballinger and flows south through the Cities of Mountlake Terrace, Shoreline, Lake Forest Park and unincorporated King County, draining to the northeast corner of Lake Washington. McAleer Creek is designated a Class AA (extraordinary) surface

water by Ecology. The mainstem of the stream is approximately 6.1 miles in length and the drainage basin is approximately 5,700 acres in size (King County 2002b). McAleer Creek originates at the outlet of Lake Ballinger at an elevation of 280 feet and flows first through a sloped channel; crosses under I-5 through a series of culverts; then flows through a steep, narrow valley before reaching a broad, flat plain near its mouth at Lake Washington. Land use in the basin is mostly residential, with a golf course, shopping center, and a section of Interstate 5 (King County 2002b). The basin also includes Lake Ballinger.

On Ecology's 1996 and 1998 303(d) water quality limited lists, McAleer Creek (Segment Id No. WA-08-1030, mouth to RM 6.1) is listed for fecal coliform bacteria (Ecology, 1996; Ecology, 1998). In the 1994 305(b) assessment (Ecology 1995), McAleer Creek (Segment Id. No.: 08-1030) is identified as supporting the following uses: rearing, harvesting and other fish spawning; salmonid spawning; and salmonid and other fish migration. This segment is impaired for primary and secondary contact recreation with impairment sources cited as highway/road/bridge construction, urban runoff/storm sewers, flow regulation/modifications, removal or riparian vegetation, in-place contaminants, natural sources, and recreational activities. The assessment identified the causes of impairments as fecal coliform bacteria and/or other pathogen indicators.

Water Quality

King County has collected water quality samples in the mainstem of McAleer Creek (Site A432) near the intersection of NE 170th and Bothell Way NE since 1979 (Table 26). Based on data collected by King County, water quality has been rated as fair to good. The waters of McAleer Creek are generally cool, slightly turbid, and well oxygenated with high total suspended solids, ammonia, nitrate nitrogen, and fecal coliform bacteria concentrations. Sporadic measurements of dissolved oxygen, and temperature do not meet specific Class AA criteria. Sampling indicates that fecal coliform bacteria levels do not meet the Class AA criterion 77 percent of the time. The data show that fecal coliform bacteria are present in the stream at high concentrations, with a mean of 233 CFU/100ml.

The McAleer Creek total phosphorus concentration is slightly elevated, with a mean concentration of 0.068 mg/L as measured by King County. The mean nitrate nitrogen concentration is high, 1.33 mg/L. Sources of nitrate nitrogen include residential fertilizer use (King County 2002a).

Based on the long-term monitoring at this site, temperature, conductivity, and ammonia have been increasing, and pH has been decreasing over the last 20 years (King County 2002a). Temperature increases could be attributed to climatic changes, removal of riparian vegetation, or some other long-term trend; however, the specific cause has not been determined (King County 2002a). The basin has undergone an increase in urbanization over the last 20 years, which could have contributed to the relatively high total suspended solids concentrations measured at this site (King County 2002a). King County does not speculate on the cause or source of the increase in ammonia in McAleer Creek (King County 2002a). The pH has also dropped at this sampling station and the cause of the decline may be attributed to urbanization and an increase in stormwater runoff (King County 2002a). Similar to Lyon Creek discussed above, fecal coliform

bacteria and enterococcus bacteria concentrations do not seem to be declining in McAleer Creek, likely due to the high amount of urbanization in the basin (King County 2002a).

Table 26. Summary of McAleer Creek ambient water quality data collected by King County and Metro from 1979 through 1999 (Site A432).

Parameter	Number of Samples	Mean	Minimum	Maximum	Class AA Standards	Number Non-Standard	Percent Non-Standard
Flow (cfs)	227	13.0	1.03	76.95	N/A	N/A	N/A
Dissolved oxygen (mg/L)	236	10.9	8	13.6	9.5	6	2.60
Temperature (°C)	256	10.5	1.5	17.4	16.0	2	0.78
Turbidity (NTU)	242	4.56	0.2	55	N/A[a]	N/A[a]	N/A[a]
pH (standard units)	235	7.61	6.61	8.2	6.5 – 8.5	0	0.00
Conductivity (μmhos/cm)	239	189	1	255	N/A	N/A	N/A
Total suspended solids (mg/L)	242	13.3	1.33	183	N/A	N/A	N/A
Ortho-phosphorus (mg/L)	238	0.032	0.001	0.106	N/A	N/A	N/A
Total phosphorus (mg/L)	240	0.068	0.025	0.415	N/A	N/A	N/A
Ammonia nitrogen (mg/L)	208	0.033	0.001	0.126	N/A[b]	N/A[b]	N/A[b]
Nitrate nitrogen (mg/L)	236	1.33	0.655	2.25	N/A	N/A	N/A
Total nitrogen (mg/L)	82	1.62	1.1	2.3	N/A	N/A	N/A
Enterococcus (CFU/100 mL)	133	232	25	8,100	N/A	N/A	N/A
Fecal coliform bacteria (CFU/100 mL)	242	233	17	9,100	50[c]	187[c]	77.3[c]

Source: King County (2002b)
N/A = Not Applicable, no surface water quality standard exists (Chapter 173-201A WAC).

[a] The turbidity standard is based on comparison of values for locations upstream (background) and downstream of turbidity sources. The application of the standard to only one location on a stream is not appropriate (N/A).
[b] The ammonia standard includes acute and chronic criteria that vary depending on pH, temperature, and the presence of salmonids. Assuming salmonids are present at typical worst-case conditions of high temperature (16°C) and high pH (8.0), acute and chronic criteria are 5.6 and 1.0 mg/L as nitrogen, respectively. The ammonia standard was not applied to the sample values.
[c] The fecal coliform bacteria standard is based on a geometric mean value (Chapter 173-201A WAC), but individual sample values were compared to this standard for determining the number and percent of non-standard values.

King County collects storm flow water quality samples in McAleer Creek at the same location as ambient sampling, near the stream's mouth at the shore of Lake Washington (Site A432) (Table 27). Based on storm samples collected from 1987 through 2000, the waters of McAleer Creek are generally cool, and well oxygenated with a neutral pH, but degraded due to high turbidity, ammonia, total suspended solids, and fecal coliform bacteria concentrations. Sampling indicates that fecal coliform bacteria concentrations do not meet Class AA criteria during storms, and sporadic dissolved oxygen concentrations do not meet applicable Class AA criterion. Based on these results, the storm water quality of McAleer Creek is characterized as fair. Sampling indicates that fecal coliform bacteria levels do not meet the Class AA criterion 96 percent of the time. The mean turbidity during storm sampling was high, 19.9 NTU. Total phosphorus concentrations are high during storm sampling, with a mean total phosphorus concentration of 0.154 mg/L. During storms, the mean nitrate nitrogen concentration is 0.927 mg/L.

When comparing storm flow versus ambient results for McAleer Creek, the mean turbidity, total suspended solids, total phosphorus, ammonia, and fecal coliform bacteria concentrations are higher during storms than those measured during monthly sampling. The mean storm dissolved oxygen concentration was essentially equal to the mean measured during baseline sampling. The mean storm flow water temperature was slightly cooler (9.6°C) than the mean measured during ambient sampling (10.46°C). The mean nitrate nitrogen concentration (0.927 mg/L) was lower during storms than during ambient sampling (1.33 mg/L), suggesting a baseflow component that is diluted during storms (King County 2002a). Total phosphorus concentrations are more than double during storms than those measured during ambient sampling. Phosphorus readily binds to particulate matter and, because during storms the amount of suspended material present is much higher than during ambient conditions, the total phosphorus concentration is also higher (King County 2002b).

Dissolved metals data were also collected by King County at this station (Site A432) from 1995 through 2000 during storm events. During storm sampling, McAleer Creek exceeded the applicable criteria for zinc once, lead three times, and nickel and copper five times each (King County 2002b).

Stream Discharge

King County collected stream discharge measurements in McAleer Creek upstream of Bothell Way for water years1992 through 1994, and the 2001 water year (King County 2002e). The average wet season (October through May) discharge was 13.0 cfs (compiled from daily average flow); the average dry season (June through September) discharge was 7.0 cfs (compiled from daily average flow).

Table 27. Summary of McAleer Creek storm water quality data collected by King County and Metro from 1987 through 2000 (Site A432).

Parameter	Number of Samples	Mean	Minimum	Maximum	Class AA Standards	Number Non-Standard	Percent Non-Standard
Flow (cfs)	1	18	18	18	N/A	N/A	N/A
Dissolved oxygen (mg/L)	46	11	9	13	9.5	3	7
Temperature (°C)	46	9.6	4.5	15.8	16	0	0
Turbidity (NTU)	47	19.9	1.5	88.0	N/A[a]	N/A[a]	N/A[a]
pH (standard units)	47	7.4	6.8	8.3	6.5 – 8.5	0	0
Conductivity (μmhos/cm)	47	149	83.0	255	N/A	N/A	N/A
Total suspended solids (mg/L)	47	65.5	4.0	422	N/A	N/A	N/A
Ortho-phosphorus (mg/L)	47	0.032	0.009	0.078	N/A	N/A	N/A
Total phosphorus (mg/L)	47	0.154	0.043	0.509	N/A	N/A	N/A
Ammonia nitrogen (mg/L)	47	0.065	0.016	0.200	N/A[b]	N/A[b]	N/A[b]
Nitrate nitrogen (mg/L)	47	0.927	0.559	1.40	N/A	N/A	N/A
Total nitrogen (mg/L)	23	1.45	1.03	2.59	N/A	N/A	N/A
Enterococcus (CFU/100 mL)	46	1,350	42	10,600	N/A	N/A	N/A
Fecal coliform bacteria (CFU/100 mL)	47	1,040	50	9,990	50[c]	45[c]	95.7[c]

Source: King County (2002a)

NA = Not Applicable, no surface water quality standard exists (Chapter 173-201A WAC).

[a] The turbidity standard is based on comparison of values for locations upstream (background) and downstream of turbidity sources. The application of the standard to only one location on a stream is not appropriate (N/A).

[b] The ammonia standard includes acute and chronic criteria that vary depending on pH, temperature, and the presence of salmonids. Assuming salmonids are present at typical worst-case conditions of high temperature (16°C) and high pH (8.0), acute and chronic criteria are 5.6 and 1.0 mg/L as nitrogen, respectively. The ammonia standard was not applied to the sample values.

[c] The fecal coliform bacteria standard is based on a geometric mean value (Chapter 173-201A WAC), but individual sample values were compared to this standard for determining the number and percent of non-standard values.

Sediment Quality

Sediment data are not collected in McAleer Creek by King County as a part of the Streams Monitoring program (King County 2002b).

Lake Ballinger

Lake Ballinger is an approximately 100-acre lake located in the Cities of Mountlake Terrace and Edmonds. The watershed is approximately five square miles in size and includes portions of the Cities of Lynnwood, Edmonds, Mountlake Terrace, and unincorporated Snohomish and King Counties (Mountlake Terrace 1993). The watershed is highly urbanized, with the lakeshore surrounded by single-family residential units. The maximum lake depth is 9.5 meters, with an average depth of 6 meters (Mountlake Terrace 1993). The major lake inflow is Hall Creek, and the only surface outflow is McAleer Creek, which drains to Lake Washington. Historic water quality problems in the Lake have included severe algal blooms, an anoxic hypolimnion, and bacterial contamination. These problems were attributed to excessive nutrient and sewage loading to the Lake (Mountlake Terrace 1993). The Lake has been characterized as eutrophic (Mountlake Terrace 1993).

Because of the Lake's degraded water quality, a two-phased restoration plan was implemented in 1979, with Phase I targeting Hall Creek, the major inflow to lake. Phase I consisted of building sedimentation facilities on Hall Creek to control sediment, stabilizing stream bank, and revegetating riparian corridors (Mountlake Terrace 1993). Phase II, which began in 1982, consisted of installation of a hypolimnetic injection and withdrawal system to increase the hypolimnetic dissolved oxygen concentration to reduce nutrient release from the anoxic lake bottom.

The combined effects of the Hall Creek rehabilitation (Phase I) and the hypolimnetic withdrawal/injection system (Phase II) improved water quality in Lake Ballinger (Mountlake Terrace 1993). However, after implementation of the restoration efforts, other factors contributed to the degradation of water quality, including raw sewage spills to Hall Creek from force main failures at a sewer pump station (Mountlake Terrace 1993). This resulted in continued degraded water quality and large phosphorus loads leading to summer algal blooms. The U.S. EPA approved a TMDL in April 1993 to address and control Lake phosphorus loads (U.S EPA 1993). Lake water quality monitoring has not occurred since 1994; therefore, current compliance with the TMDL load allocation limits remains unknown.

Lake Ballinger is not listed on Ecology's 1996 or 1998 303(d) water quality limited lists for any water quality parameters because once the U.S. EPA approves a TMDL, Ecology does not list the water body or impairments identified in the TMDL. However, this may change with the publication of the 2002 303(d) list because those waterbodies subject to a TMDL may be included. Lake Ballinger is included on the 1994 305(b) list as impaired for aesthetic enjoyment due to nutrient loadings.

Hall Creek

Hall Creek is the major outlet of Hall Lake, located in the City of Lynnwood. Hall Lake is a privately owned Lake approximately 7.5 acres in size with a mean depth of 30 feet. The watershed is highly urbanized with a lakeshore consisting entirely of residential dwellings. The Lake has been characterized as eutrophic (Mountlake Terrace 1993). The stream's watershed is highly urbanized and receives runoff from industrial areas, highways, and a freeway; the mean

annual discharge of the stream of approximately 5 cfs (Mountlake Terrace 1993). The stream is classified a Class AA (extraordinary) surface water by Ecology (Ecology 1997a). The outlet of Chase Lake, a small urban lake located in the City of Edmonds, flows into Hall Creek just upstream of Lake Ballinger.

As part of the Lake Ballinger Study conducted by the City of Mountlake Terrace, water quality samples were collected at six stations along the stream during 1991. The stream was monitored for physical, chemical, biochemical, and biological parameters. During sampling, stream water quality was fair to good. All stations recorded violations of Class AA standards for water temperature and dissolved oxygen. All pH measurements were within the standard range of 6.5 to 8.5 standard units. High turbidity was measured at one station, which receives runoff from industrial and commercial areas associated with SR 99. Fecal coliform bacteria were measured at two sampling stations, and concentrations ranged from 23 to 9200 CFU/100 mL, which exceeds the Class AA criterion (Mountlake Terrace 1993). The total phosphorus concentration in Hall Creek ranged from 20 µg/L to 250 µg/L (Mountlake Terrace 1993). Within the watershed, sources of phosphorus include detergents, sediment transport, fertilizer, and raw sewage spills (Mountlake Terrace 1993).

Comparison of Creek Basin Surface Water Quality

Comparisons of mean water quality parameters collected at the mouth of Little Bear Creek, North Creek, Swamp Creek, McAleer Creek and Lyon Creek by King County from 1979 to 1999 are shown on Charts WQ1 and WQ2 (Attachment A). The graphical comparisons are shown for the following water quality parameters: total phosphorus, ammonia, nitrate, dissolved oxygen, temperature, turbidity and fecal coliform bacteria.

North Creek had the highest mean total phosphorus concentration (0.089 mg/L) and Lyon Creek had the lowest total phosphorus concentration (0.063 mg/L). North Creek also had the highest mean ammonia concentration, 0.038 mg/L. McAleer and Lyon Creeks had the highest nitrate nitrogen mean concentrations, exceeding 1.2 mg/L. McAleer Creek also had the highest mean water temperature of the five streams monitored and is likely due to the highly urbanized condition in the basin. Little Bear Creek had the highest mean dissolved oxygen concentration (11.03 mg/L). However, during baseline sampling, all streams had mean dissolved oxygen concentrations greater than 10.0 mg/L, meeting the Class AA minimum criterion of 9.5 mg/L. The highest mean turbidity was measured in Lyon Creek (4.85 NTU), a highly urbanized watershed. Little Bear Creek and McAleer Creek also had high mean turbidities, greater than 4 NTU. The mean fecal coliform bacteria concentrations were high and ranged from 180 CFU/100 mL in Swamp Creek to 383 CFU/100 mL in Lyon Creek, exceeding the Class AA minimum criterion of 50 CFU/100 mL.

Puget Sound Basin

The proposed project would have conveyance corridors that cross through a combination of the following surface water basins that drain into Puget Sound: Willow Creek (in Edmonds), Barnacle Creek (in Shoreline), and Storm Creek (in Shoreline). Willow Creek is discussed under Existing Water Quality: Treatment Plant earlier in this report.

Barnacle Creek

The mainstem of Barnacle Creek originates just north of N 204th Street in the City of Shoreline. Barnacle Creek flows southwest under N 204th Street and west through highly developed residential neighborhoods, paralleling the City boundary with Snohomish County. Barnacle Creek then flows through a 600-foot piped section under Richmond Beach Drive NW and continues west in an open channel, entering a wet area east of the Burlington Northern Santa Fe railroad. The south stem joins the main stem before the stream flows through a culvert and into Puget Sound (Tetra Tech 2003). Barnacle Creek is considered a Class AA surface water by Ecology because it flows into Puget Sound, which is classified as a Class AA water body (Ecology 1997a).

The City of Shoreline has collected water quality data near the mouth of Barnacle Creek. Parameters include pH, dissolved oxygen, temperature, conductivity, and turbidity. Data from October 2001 through December 2002 indicate that water quality is fair to good, with dissolved oxygen and temperature values not meeting Class AA standards on occasion during the summer months (Loch 2003). Table 28 summarizes water quality data collected for Barnacle Creek.

Table 28. Barnacle Creek summary of water quality data collected by the City of Shoreline from 2001 through 2002.

Parameter	Number of Samples	Mean	Minimum	Maximum
Dissolved oxygen (mg/L)	24	10.3	8.6	11.9
Temperature (°C)	24	10.8	6.2	17.1
Turbidity (NTU)	17	4.8	0.0	18.2
pH (standard units)	24	7.7	7.4	8.0
Conductivity (μmhos/cm)	24	167	116	201

Source: Loch 2003

Storm Creek

Storm Creek originates in seeps and wetlands in Snohomish County. Storm Creek is piped for approximately half of its length, flowing south from the headwaters in Snohomish County to the first open channel reach near NW 191st Street in the City of Shoreline. The stream then flows southwest through a residential neighborhood, within a steep ravine and highly modified channel, to Puget Sound (Tetra Tech, 2003). Storm Creek is considered a Class AA surface water by Ecology because it flows into Puget Sound, which is classified as a Class AA water body (Ecology 1997a).

The City of Shoreline has collected water quality data in two locations along Storm Creek. The upper station is located downstream of the end of the piped section at the intersection of 15th Avenue NW and NW 190th Street. The lower station is located upstream of 17th Avenue NW, near the mouth of the stream. Parameters include pH, dissolved oxygen, temperature, conductivity, and turbidity. Data collected from September 2001 through December 2002 at the upstream location (downstream of the end of the piped section) indicate that water quality is fair to good, with dissolved oxygen and temperature values not meeting Class AA standards on

occasion during the summer months. Water quality at the downstream location is similar to the upstream location. Continuous temperature data collected at the downstream location in August 2001 indicates that temperature values did not meet Class AA standards during the summer months (Loch 2003). Tables 29 and 30 summarize water quality data collected for the lower and upper locations on Storm Creek.

Table 29. Storm Creek summary of water quality data collected by the City of Shoreline from 2001 through 2002 (Lower station).

Parameter	Number of Samples	Mean	Minimum	Maximum
Dissolved oxygen (mg/L)	26	10.6	8.0	12.4
Temperature (°C)	26	10.8	5.3	15.8
Turbidity (NTU)	19	1.0	0.0	4.0
pH (standard units)	26	7.8	7.1	8.2
Conductivity (μmhos/cm)	26	174	120	213

Source: Loch 2003

Table 30. Storm Creek summary of water quality data collected by the City of Shoreline from 2001 through 2002 (Upper station).

Parameter	Number of Samples	Mean	Minimum	Maximum
Dissolved oxygen (mg/L)	26	10.5	9.1	11.8
Temperature (°C)	26	11.3	7.1	16.8
Turbidity (NTU)	19	2.6	0.0	8.9
pH (standard units)	26	7.9	6.9	8.3
Conductivity (μmhos/cm)	26	184	116	227

Source: Loch 2003

Sammamish River

The Sammamish River is approximately 13.8 miles long and flows north and west from Lake Sammamish, entering Lake Washington near the City of Kenmore. The River serves as the main outlet of Lake Sammamish and is designated by Ecology as a Class AA water (extraordinary) (Ecology 1997a). Major tributaries of the Sammamish River include Bear-Evans Creek, Little Bear Creek, North Creek, and Swamp Creek. The Sammamish River flows through a broad, flat floodplain varying only 30 feet in elevation (Metro 1990). Land use in the basin includes residential, commercial, light industrial, and agricultural uses.

The Sammamish River has been modified extensively by the U.S. Army Corps of Engineers to minimize flooding. Modifications include dredging and channeling of the River and constructing a weir at the outlet of Lake Sammamish to regulate flow (WDFW 1975). Historically, most of the natural riparian vegetation along the riverbanks has been removed. Currently, King County and other agencies (i.e. the Army Corps of Engineers and the City of

Redmond) are in the process of re-establishing vegetation along portions of the riparian corridor through the Sammamish River Restoration Project.

Three segments of the Sammamish River are listed on Ecology's 1998 303(d) list of threatened and impaired water bodies (Ecology 1998). Table 31 lists the location and limiting parameters for listing of the Sammamish River.

Table 31. Locations of 1998 303(d) listed waterbodies on the Sammamish River

Location	Limiting parameter
At outlet to Lake Washington	Temperature, fecal coliform bacteria
Downstream of confluence with North Creek	Temperature, fecal coliform bacteria, dissolved oxygen
Upstream and downstream of confluence with Bear Creek, within Redmond	Temperature, fecal coliform bacteria, pH

Source: Ecology (1998)

Water Quality

Findings reported in the Sammamish River Corridor Action Plan (Tetra Tech 2002) indicate that water quality in the Sammamish River is poor. The Sammamish River Action Plan is a planning document produced by the U.S. Army Corps of Engineers and King County Department of Natural Resources and Parks. The Sammamish River Action Plan outlines action items intended to restore habitat in the Sammamish Corridor that would benefit native fish, birds, and other wildlife as well as enhance the area for the enjoyment of the surrounding community. The plan focuses on the Sammamish River as a migratory corridor for all anadromous salmon in the Sammamish watershed. Temperature was a primary interest and it was found that temperatures in the Sammamish River are frequently in the lethal range for salmon species.

Ecology and King County have collected water quality samples in the Sammamish River. Sampling site locations and monitoring periods are listed in Table 32.

Table 32. Sammamish River water quality monitoring stations and duration of sampling.

Sampling Location	Water Quality Sampling Record	Agency	Frequency of Sampling
Kenmore (Site 0450)	1979-present	King County	Monthly
Bothell (Station 08B070)	1959-1999	Ecology	Monthly

Source: Ecology (2002b) and King County (2002a).

King County collects ambient water quality samples monthly at the mouth of the Sammamish River near Kenmore (Site 0450) (Table 33). Based on data collected from 1979 through 1999, the River's water quality is considered degraded because of elevated total suspended solids concentrations, warm temperatures, high fecal coliform bacteria concentrations, and low dissolved oxygen concentrations. Sampling indicates that water temperature, fecal coliform bacteria, and dissolved oxygen do not meet applicable Class AA water quality criteria. Water temperature did not meet the Class AA minimum criterion of 16.0 °C 28 percent of the time. Dissolved oxygen did not meet the minimum Class AA criterion of 9.5 mg/L 11 percent of time. At Kenmore, the high water temperatures can be attributed to the wide, sluggish River that supports little or no riparian vegetation (King County 2002a). These high water temperatures are the primary cause of sub-standard dissolved oxygen concentrations (King County 2002a). Fecal coliform bacteria are present in the stream at relatively high concentrations, with a mean of 207 CFU/100 mL. Occasionally, pH is less than Class AA criteria.

The Sammamish River total phosphorus concentration is slightly elevated, with a mean concentration of 0.060 mg/L. The mean nitrate nitrogen concentration is also elevated at 0.52 mg/L. Sources of nitrate nitrogen include residential fertilizer use (King County 2002a). In the Sammamish River, nitrate nitrogen concentrations are highest in the winter and gradually diminished through the growing season as plant uptake increases (King County 2002a).

Based on the long-term monitoring at this station by King County, the data have exhibited a decreasing trend in pH, fecal coliform bacteria, total phosphorus, and ortho-phosphorus, and an increasing trend in temperature and conductivity (King County 2002a). Temperature increases can be attributed to climatic changes, removal of riparian vegetation, or some other long-term trend; however, the specific cause has not been determined (King County 2002a). The decline in phosphorus concentrations may be due to the implementation of best management practices in the watershed (King County 2002a). The pH has also dropped at this sampling station; the cause of the decline may be attributed to urbanization and an increase in stormwater runoff (King County, 2002a). As part of the ambient monitoring program, King County does collect storm event water samples in the Sammamish River, however these samples are typically analyzed for conventional parameters only. Conductivity may be linked to flows and land use changes in the basin (King County 2002a).

Table 33. Summary of Sammamish River ambient water quality data collected by King County from 1979 through 1999 at Kenmore (Site 0450).

Parameter	Number of Samples	Mean	Minimum	Maximum	Class AA Standards	Number Non-Standard	Percent Non-Standard
Dissolved oxygen (mg/L)	229	9.8	6.7	13.7	9.5	26	11
Temperature (°C)	240	12.3	0.7	23.6	16	67	28
Turbidity (NTU)[a]	231	3.91	0.3	27	N/A[a]	N/A[a]	N/A[a]
pH (standard units)	230	7.17	6.3	8.1	6.5 – 8.5	3	1
Conductivity (μmhos/cm)	229	131	85	205	N/A	N/A	N/A
Total suspended solids (mg/L)	235	7.29	0.01	54.7	N/A	N/A	N/A
Ortho-phosphorus (mg/L)	217	0.028	0.004	0.272	N/A	N/A	N/A
Total phosphorus (mg/L)	230	0.060	0.020	0.581	N/A	N/A	N/A
Ammonia nitrogen (mg/L)	214	0.042	0.001	0.127	N/A[b]	N/A[b]	N/A[b]
Nitrate nitrogen (mg/L)	228	0.517	0.14	1.55	N/A	N/A	N/A
Total nitrogen (mg/L)	77	0.852	0.504	1.6	N/A	N/A	N/A
Enterococcus (CFU/100 mL)	127	65	4	3,000	N/A	N/A	N/A
Fecal coliform bacteria CFU/100 mL)	231	207	9	13,000	50[c]	187[c]	77[c]

Source: King County (2002a)
NA = Not Applicable, no applicable surface water quality standard exists (Chapter 173-201A WAC).

[a] The turbidity standard is based on comparison of values for locations upstream (background) and downstream of turbidity sources. The application of the standard to only one location on a stream is not appropriate (N/A).
[b] The ammonia standard includes acute and chronic criteria that vary depending on pH, temperature, and the presence of salmonids. Assuming salmonids are present at typical worst-case conditions of high temperature (16°C) and high pH (8.0), acute and chronic criteria are 5.6 and 1.0 mg/L as nitrogen, respectively. The ammonia standard was not applied to the sample values.
[c] The fecal coliform bacteria standard is based on a geometric mean value (Chapter 173-201A WAC), but individual sample values were compared to this standard for determining the number and percent of non-standard values.

King County collected quarterly water quality data on the Sammamish River as part of the Sammamish-Washington Assessment and Modeling Project (SWAMP) from 2000 to 2002. This project is being conducted to provide a comprehensive evaluation of water and sediment quality in the Greater Lake Washington watershed. The information will be used to support salmon recovery planning, assist with the development of habitat conservation plans associated with wastewater discharges in King County, and assist with the evaluation of using reclaimed water in the watershed. Water quality samples were analyzed for dissolved and total low-level metals (including mercury, copper, lead, and zinc), conventionals (including dissolved oxygen, temperature, and nutrients) and organic compounds (including semivolatiles, chlorinated pesticides/PCBs, organophosphorus pesticides, and chlorinated herbicides). The data are currently being reviewed and analyzed and will be used in the SWAMP risk assessment to develop water quality loading models to support future planning and conservation efforts. King County Department of Natural Resources Water and Land Resources Division is coordinating this effort, and should be completing the initial screening phase by December 2004.

King County has also collected water quality data for the Sammamish River in support of several projects in the Sammamish watershed, including a reclaimed water facility proposed for siting in the Sammamish Valley. Water samples were collected from ten locations once a year from 2001 to 2003. Water, sediment, and benthos samples were collected for 2001 and 2003. Only water samples were collected for 2002. Sampling locations were situated just downstream of major tributaries and potential pollution sources. Water samples were analyzed for metals, inorganics, organics, bacteria, and pesticides. A summary report is in the process of being completed. King County Department of Natural Resources Water and Land Resources Division should be contacted to inquire about the status of the report.

Based on data collected by Ecology, water quality in the Sammamish River at Bothell is similar to that found at the King County monitoring site (Table 34). The River's water quality near Bothell is degraded due to warm water temperatures, high fecal coliform bacteria concentrations, high turbidity and total suspended solids, and low dissolved oxygen concentrations.

Lake Washington

Lake Washington is the largest lake in King County, and the second largest natural lake in Washington with a drainage area of 472 square miles and a surface area of 21,500 acres (King County 2002g). The Lake has a mean depth of 108 feet, a maximum depth of 214 feet, and a volume of 2.35 million acre-feet (King County 2002g). The Lake flushes approximately 0.43 times per year, so that the net residence time in the lake ranges from 2 to 3 years (King County 2002g). The main inflows to the Lake are the Cedar River (57 % hydraulic load) in the south at Renton and the Sammamish River (27 % hydraulic load) in the north end at Kenmore; both are also the major phosphorus loading sources to the Lake (King County 2002g). The Cedar River contributes approximately 25 percent of the total phosphorus to the Lake, while the Sammamish River contributes approximately 41 percent of the total phosphorus load (King County 2002g). The main outlet of the Lake is the Ship Canal to Puget Sound (King County 2002g). The Lake Washington watershed is considered urban, with approximately 63 percent of its area developed (Metro 1989).

Table 34. Sammamish River summary of ambient water quality data collected by Ecology from 1959 through 1999 at Bothell (Station 08B070).

Parameter	Number of Samples	Mean	Minimum	Maximum	Class AA Standards	Class AA Violations	Percent Not Meeting Standard
Flow (cfs)	313	409	8	2,700	N/A	N/A	N/A
Dissolved oxygen (mg/L)	382	10.0	6.4	13.2	9.5	130	34
Temperature (°C)	383	11.9	2.2	23.9	16.0	99	26
Turbidity (NTU)	301	7.32	0.1	120	NA[a]	NA[a]	NA[a]
pH (standard units)	373	7.2	6.3	8	6.5-8.5	1	<1
Conductivity (μmhos/cm)	371	124	30	241	N/A	N/A	N/A
Total suspended solids (mg/L)	208	11.3	2	110	N/A	N/A	N/A
Ortho phosphate (dissolved) (mg/L)	276	0.020	0.007	0.14	N/A	N/A	N/A
Total phosphorus (mg/L)	274	0.056	0.01	0.21	N/A	N/A	N/A
Ammonia-nitrogen (mg/L)	277	0.078	0.01	0.51	N/A[b]	N/A[b]	N/A[b]
Nitrate – nitrite nitrogen (mg/L)	183	0.33	0.01	1	N/A	N/A	N/A
Total persulfate nitrogen (mg/L)	24	0.79	0.463	1.3	N/A	N/A	N/A
Fecal coliform bacteria (CFU/100mL)	258	413	8	9,400	50[c]	222[c]	86[c]

Source: Ecology (2002b)
NA = Not Applicable, no applicable surface water quality standard exists (Chapter 173-201A WAC).

[a] The turbidity standard is based on comparison of values for locations upstream (background) and downstream of turbidity sources. The application of the standard to only one location on a stream is not appropriate (N/A).

[b] The ammonia standard includes acute and chronic criteria that vary depending on pH, temperature, and the presence of salmonids. Assuming salmonids are present at typical worst-case conditions of high temperature (16°C) and high pH (8.0), acute and chronic criteria are 5.6 and 1.0 mg/L as nitrogen, respectively. The ammonia standard was not applied to the sample values.

[c] The fecal coliform bacteria standard is based on a geometric mean value (Chapter 173-201A WAC), but individual sample values were compared to this standard for determining the number and percent of non-standard values.

Between 1941 and 1963, Lake Washington received increasing amounts of secondary sewage, and water quality declined to the point where the Lake became eutrophic. Sewage was diverted beginning in 1963 through 1967, with the discharge of untreated effluent eliminated by 1968, except for combined sewer overflows (King County 2002g). Rapid water quality improvements followed with the reduction of blue-green algae to insignificant levels by 1976 (King County 2002g). Water quality improvements have been documented and the Lake is currently classified as mesotrophic (King County 2002g).

Water Quality

King County collects water quality data at several Lake Washington water quality stations, including one located near the City of Kenmore at the north end of the lake near the mouth of the Sammamish River (Site 0804). Recent data collected by King County indicate that Lake Washington has good water quality with low productivity (King County 2001). Lake Washington is listed on Ecology's 1998 303(d) water quality limited list in several locations for fecal coliform bacteria and in one location for sediment bioassay (Ecology 1998**)**.

Based on data collected by King County, the overall water quality of Lake Washington is good, and the Lake remains in a mesotrophic state (i.e., having moderate transparency and moderate levels of nutrients and algae) (King County 2002g). Based on data collected from January 1997 through April 2002 at a depth of approximately 1 meter near Kenmore (Site 0804), Lake Washington waters are generally cool, and well oxygenated, and have a neutral pH (Table 35). Sampling indicates that fecal coliform bacteria concentrations are low, with a mean of 10.1 CFU/100 mL (measured at 1 meter). The mean chlorophyll-a concentration is 5.73 mg/m^3 (composite sample).

As part of the quarterly SWAMP monitoring, King County collected water quality data on organic constituents and metals in the water column at several Lake Washington stations, including the site near Kenmore (site 0804). At this time, data collected in support of the quarterly SWAMP monitoring are being reviewed and analyzed and are not available. King County Department of Natural Resources Water and Land Resources Division should be contacted to inquire about the status of any reports regarding this data.

Table 35. Water quality samples collected in Lake Washington (approximately 1 meter) by King County near Kenmore (Site 0804).

Parameter	Number of Samples	Mean	Minimum	Maximum	Lake Class Standards	Lake Class Violations	Percent Not Meeting Standard
Sample Depth (meters)	117	1.00	0.8	1.6	N/A[a]	N/A	N/A
Temperature (°C)	101	13.98	6	24.3	No measurable change from natural conditions.	ND[c]	ND
Dissolved Oxygen (mg/L)	88	10.35	8.38	12.9	No measurable change from natural conditions.	ND	ND
pH (Standard Units)	88	7.79	7.1	8.85	No measurable change from natural conditions.	ND	ND
Conductivity (μmhos/cm)	88	101	83.2	121.7	N/A	N/A	N/A
Fecal coliform bacteria (CFU/100 mL)	65	10.1	0	61	50[b]	1	1
Enterococcus (CFU/100 mL)	65	6.41	0	45	N/A[d]	N/A[d]	N/A[d]
Total Nitrogen (mg/L)	64	0.394	0.198	0.914	N/A	N/A	N/A
Secchi Disc (meters)	98	0.39	1	7.5	N/A	N/A	N/A
Chlorophyll-a (mg/m^3)	101	5.98	0.21	22.1	N/A	N/A	N/A
Hardness (mg/L as $CaCO_3$)	10	39.87	36.4	48.3	N/A	N/A	N/A

Source: King County (2002h).

[a] NA = Not Applicable, no applicable surface water quality standard exists (Chapter 173-201AWAC).

[b] The fecal coliform criterion applies to a geometric mean and not a single measurement (Chapter 173-201A).

[c] ND = Not determined. Variation from the baseline condition was not determined. These sampling results are the baseline condition.

[d] There are currently no freshwater state standards for enterococcus (Chapter 173-201A).

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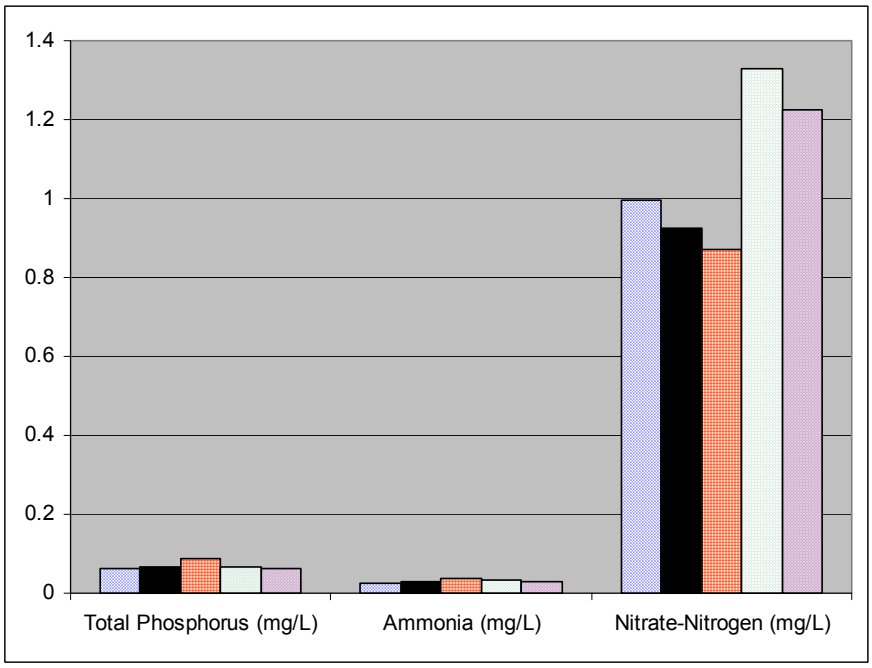
ATTACHMENT A – WATER QUALITY CHARTS

to Technical Appendix 6-A

Figure WQ1: Comparison of water quality data for select parameters collected at the mouth of five Lake Washington basin streams.

(The data shown are the mean values collected from 1979-1999. Source: King County, 2002b)



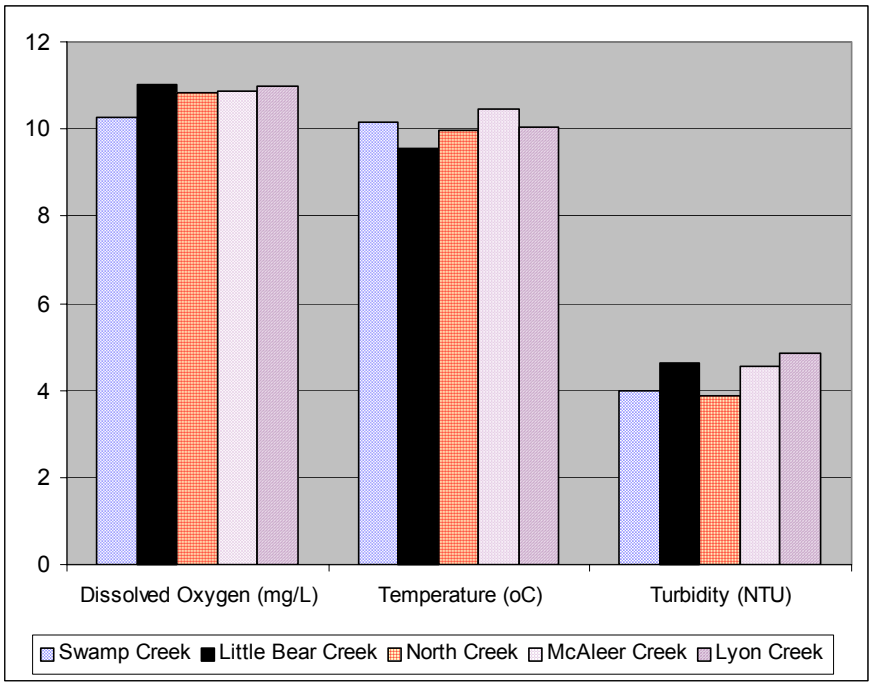


Figure WQ2: Comparison of fecal coliform bacteria concentrations collected at the mouth of five Lake Washington basin streams.

(The data shown are the mean values collected from 1979-1999. Source: King County, 2002b)